INSTRUCTION MANUAL

Gertsch*

VARIABLE PHASE STANDARD

MODEL VPS-1, QS-1, NI-4

Gertsch*
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Sensitive Research*
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Precision electrical and electronic instruments for measurement

THE SINGER COMPANY • METRICS DIVISION

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Figure 1-1. Variable Phase Standard Model VPS-1/QS-1/NI-4

ADDENDUM

TO

MODEL VPS-1, QS-1, NI-4

VARIABLE PHASE STANDARD

INSTRUCTION BOOK

A. ADDITIONAL OPERATING INSTRUCTIONS.

1. To synchronize the internal oscillator to an external frequency source, proceed as follows:

   a. Connect frequency source with an amplitude of approximately 1 to 3 vrms to jacks J1 and J2 (on the back of the Model VPS-1). The frequency source must be within ± 5% of one of the Model VPS-1 frequencies.

   b. Turn FREQUENCY switch to the applicable frequency position.

   c. Turn SYNC/EXT OSC switch on rear panel S5 to the SYNC position.

   d. Check that the reference output voltage available at jacks J7 and J8 is synchronized to the frequency source. If necessary, increase amplitude of frequency source until synchronization is indicated by means of a Lissajous pattern with an oscilloscope.

   e. Proceed with pre-operation adjustments as outlined in paragraph 1-41 of the Instruction Book.

2. To operate the Model VPS-1 from an external oscillator, proceed as follows:

   a. Connect external oscillator to jacks J1 and J2 (on the back of the Model VPS-1). The external oscillator must be a stable source with an amplitude of 50 vrms ± 5% and with a frequency within ± 5% of one of the Model VPS-1 frequencies.

   NOTE

   For this application, an oscillator network Z1 is not required but a quadrature network Z2 of the required frequency must be installed.

   b. Turn FREQUENCY switch to the applicable frequency position.

   c. Turn SYNC/EXT OSC switch S5, on rear panel, to the EXT OSC position.

   NOTE

   At completion of tests, return switch to the SYNC position and remove the external oscillator. The switch must be in the SYNC position to operate the unit from the internal oscillator.

   d. Proceed with pre-operation adjustments as outlined in paragraph 1-41 of the Instruction Book.

3. To operate the system as a complex ratio bridge, proceed as follows:

   a. Calibrate the system as outlined in paragraphs 1-49 through 1-53.

   b. Adjust Model VPS-1 as outlined in paragraph 1-41.

   c. Turn QUADRANT switch to the 0°-90° quadrant.

   d. Interconnect equipment as shown on the attached figure 1.

e. Turn REFERENCE switch of Model NI-4 to IN-PHASE.

f. Check deflection of the null meter of the Model NI-4. If meter deflects to the left of center, turn QUADRANT switch to the 90°-180° or 180°-270° position.

g. Adjust IN-PHASE controls of Model VPS-1 as required to obtain a null on the null meter of the Model NI-4.

h. Turn REFERENCE switch of Model NI-4 to QUADRATURE.

i. Check deflection of the null meter of the Model NI-4. If meter deflects to the left of center, turn QUADRANT switch to the 180°-270° or 270°-360° position. If quadrant is changed, repeat step f.

j. Adjust QUADRATURE controls of Model VPS-1 as required to obtain a null on the null meter of the Model NI-4.

NOTE

Always null out the quadrature component even if the quadrature ratio is not required. The quadrature component will obscure the in-phase nulls and can cause erroneous readings. Since the amplification factor of the Model NI-4 is approximately 7,000, even very small quadrature components will effect the readings.

k. Repeat steps e through j.

l. Read Rx value from the IN-PHASE controls of the Model VPS-1.

m. Read Rjy value from the QUADRATURE controls of the Model VPS-1.

n. Since the readout is in rectangular coordinates, the phase angle of the signal voltage can be determined. The phase angle has a tangent of $\frac{Rjy}{Rx}$. Compute the tangent and refer to a standard trigonometric table to find the angle.

4. Expanded adjustment procedure for Model QS-1.

NOTE

Operate right hand and left hand controls simultaneously during adjustment procedures.

a. Turn FUNCTION switch to position 1 (GAIN).

(1) If meter deflects to the left (of center null), turn both GAIN controls CW until null is obtained. Operate the coarse and vernier controls in the same manner.

(2) If meter deflects to the right, turn both GAIN controls CCW until null is obtained.

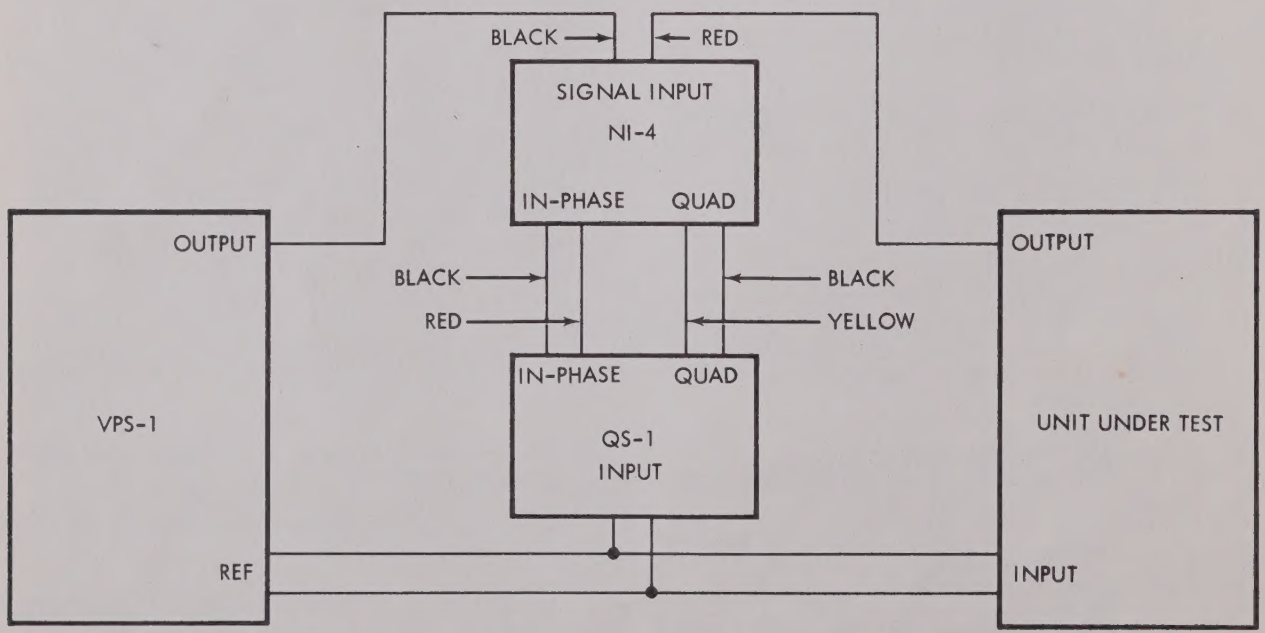


Figure 1. Interconnections for Complex Ratio Bridge Measurements

b. Turn FUNCTION switch to position 2 (GAIN).

(1) If meter deflects to the left, turn RH GAIN control CW and LH GAIN CONTROL CCW from position 1 to position 2.

(2) If meter deflects to the right, turn RH GAIN control CCW and LH GAIN control CW until null is obtained.

c. Repeat steps a and b until the meter remains at null when the FUNCTION switch is turned from position 1 to position 2.

d. Turn FUNCTION switch to position 3 (PHASE).

(1) If meter deflects to the left, turn both PHASE controls CCW until null is obtained.

(2) If meter deflects to the right, turn both PHASE controls CW until null is obtained.

e. Turn FUNCTION switch to position 4 (PHASE).

(1) If meter deflects to the left, turn RH PHASE control CW and LH PHASE control CCW until null is obtained.

f. Repeat steps d and e until the meter remains at null when the FUNCTION switch is turned from one position to the next.

g. Repeat steps a through f until the meter remains at null when the FUNCTION switch is turned through all four positions.

h. Turn FUNCTION switch to OPERATE and proceed.

B. ADDITIONAL MAINTENANCE INSTRUCTIONS.

1. To add a frequency proceed as follows:

a. Install oscillator network Z1 in socket for selected channel (Model VPS-1).

b. Remove resistor R52 or R53 from pins 5 and 7 of the quadrature network socket for the selected channel (Model VPS-1).

CAUTION

Either a quadrature network or a feed back resistor must be installed. If the frequency switch is turned to a channel without a feed back path, damage to the equipment may result. To remove a network, turn the frequency switch away from that channel. Install a 39K ± 10%, 1/2 watt resistor between pins 5 and 7 until the network is returned.

c. Install two quadrature networks Z101 and Z201 in sockets for selected channel (Model QS-1).

d. Install filter FL100 in socket for selected channel (Model NI-4). As shipped from the factory, the channel capacitors are selected for the following frequencies.

CHANNEL	FREQUENCY	CAPACITOR	VALUE
A	150 to 600	C123	0.1 uf
B	300 to 1200	C124	0.033 uf
C	800 to 3200	C125	0.0127 uf

e. Connect a frequency counter and a vacuum tube voltmeter to the reference jacks J7 and J8.

f. Turn Model VPS-1 on and allow a 30 minute warm-up.

g. Check that required frequency can be set with FREQUENCY vernier control. Check that output amplitude is 50 vrms ± 5%. If necessary readjust the two trimmer capacitors of the oscillator network to set frequency and amplitude.

h. Proceed with calibration as outlined in paragraphs 1-49 through 1-53 of the Instruction Book.

2. POWER SUPPLY ADJUSTMENTS.

NOTE

All of the plate supply voltages are electronically regulated and have controls for adjustment. Each is measured with respect to chassis and must be adjusted in the following sequence after a 60 minute warm-up.

a. -300V SUPPLY.

(1) Connect DC voltmeter to chassis and the outer case solder lug (negative) on capacitor C205B.

(2) Adjust potentiometer R223 (rear panel) for -300V DC.

b. +200V SUPPLY.

(1) Connect DC Voltmeter between chassis and the positive terminal on capacitor C203B.

(2) Adjust potentiometer R222 for +200V DC.

c. +450V SUPPLY.

(1) Connect DC Voltmeter between chassis and the positive terminal of capacitor C201B.

(2) Adjust potentiometer R208 for +450V DC.

3. REFERENCE VOLTAGE ADJUSTMENT.

NOTE

The reference voltage is set at the factory to a standard level. Do not readjust unless the voltage varies more than ± 5% from 50 vrms.

a. Connect AC VTVM across the REFERENCE terminals.

b. Adjust potentiometer R14 as required to obtain a 50 vrms ± 5% reference output.

4. BALANCE ADJUSTMENT.

a. Adjust Model VPS-1 as outlined in paragraph 1-41 of the Instruction Book.

b. With an oscilloscope, measure voltage between capacitor C9 and chassis. The voltage should be approximately 50 vrms (144V peak-to-peak).

c. Connect oscilloscope between capacitor C21 and ground.

d. Adjust potentiometer R84 until voltage at capacitor C21 equals voltage measured at capacitor C9.

e. Adjust BALANCE control for null on meter.

f. Set CALIBRATE switch to OPERATE.

g. Check that Model VPS-1 meter indicates a null. If not, readjust potentiometer R84.

SECTION I
USE AND MAINTENANCE

1-1. INTRODUCTION AND DESCRIPTION.

1-2. IDENTIFICATION. This publication provides instructions and a parts breakdown for Model No. VPS-1/QS-1/NI-4 Variable Phase Standard, Part Number AA946, manufactured by Gertsch Products, Inc., Los Angeles, California.

1-3. PURPOSE. The Model VPS-1 Variable Phase Standard generates two signals differing in phase by any desired angle from 0 to 360 degrees. The reference or zero degree signal has a fixed amplitude of 50 volts (rms). The vector output has a maximum amplitude of 50 volts (rms) and may be attenuated in steps of 50 millivolts within the range of 0 to 50 volts (rms). The Model NI-4 Null Indicator and the Model QS-1 Quadrature Standard are used to calibrate the variable phase standard. The quadrature generator generates an output signal which is 90 degrees out of phase with an incoming signal. The null indicator forms an ac bridge circuit to detect any differences between two inputs.

1-4. DESCRIPTION. (See figure 1-1.) The three units are contained within a metal case. Each of the units can be operated separately and only require connection to an alternating current power source. Interconnecting cables are furnished with the unit. Leading particulars are listed in figure 1-2.

1-5. PRINCIPLES OF OPERATION.

1-6. VARIABLE PHASE STANDARD.

1-7. GENERAL PRINCIPLES. (See figure 1-3.) A local oscillator generates a reference signal which is supplied to the reference output jacks through an isolation amplifier. Generation of the vector signal with a known phase angle is accomplished by summing the inphase and the quadrature components of the reference signal. After summation, the vector signal is supplied to the vector output jacks either directly or through an attenuator circuit.

1-8. A quadrature generator generates a signal which is 90 degrees out of phase with the reference signal. After amplification, the quadrature signal drives one variable transformer. The reference signal drives a second variable transformer which supplies the inphase component. The outputs of the two variable transformers are combined to form the vector signal.

1-9. In operation, the angle of the vector signal is controlled by the settings of the two variable transformers. The inphase transformer is set to the cosine of the desired angle and the quadrature transformer is set to the sine of the desired angle. Each transformer has six decades of resolution, corresponding to six place trigonometric tables.

VARIABLE PHASE STANDARD	
Frequency	Any one of three fixed frequencies in the 150 to 3000 cps range. Each frequency can be adjusted within a ±5% range
Output Voltage:	
Reference Signal	50 v rms
Vector Signal	Variable from 0 to 50 v rms in 50 mv steps
Vector:	
Range	Continuously variable from 0 to 360 degrees
Angular Accuracy	±0.05 degree at any angle
Resolution	1 minute
NULL INDICATOR	
Type	Phase sensitive
Frequency Range	50 to 3000 cps
Sensitivity	100 uv
Input Impedance	1 megohm minimum
Input Reference Voltage	
Amplitude	3 ranges: 1 to 5 v 5 to 25 v 25 to 125 v (0.35 times frequency in cps maximum)
QUADRATURE STANDARD	
Phase Shift	90 degrees
Accuracy	±0.01 degree
Frequency Range	Any one of three fixed frequencies in the 150 to 3000 cps range
Signal Input Voltage	5 to 50 v rms maximum
Signal Output Voltage	5 v rms maximum
POWER REQUIREMENTS.	115/230 vac, 50 to 400 cps, single phase
OVERALL DIMENSIONS:	
Height	24-1/2 inches
Width	21-3/4 inches
Depth	20 inches
WEIGHT	100 pounds (approx)

Figure 1-2. Table of Leading Particulars

1-10. In order for the system to generate accurate vectors, the input signals to the two transformers must have precisely equal amplitudes. Each transformer includes a reference winding which monitors the input level. Any differences in the input levels are detected by an AGC circuit which controls the level of the quadrature component.

1-11. The AGC circuit consists of an ac bridge, amplifiers, an ac to dc conversion circuit, and a photocell circuit. The input signals from the monitor windings are fed to the ac bridge which detects any differences

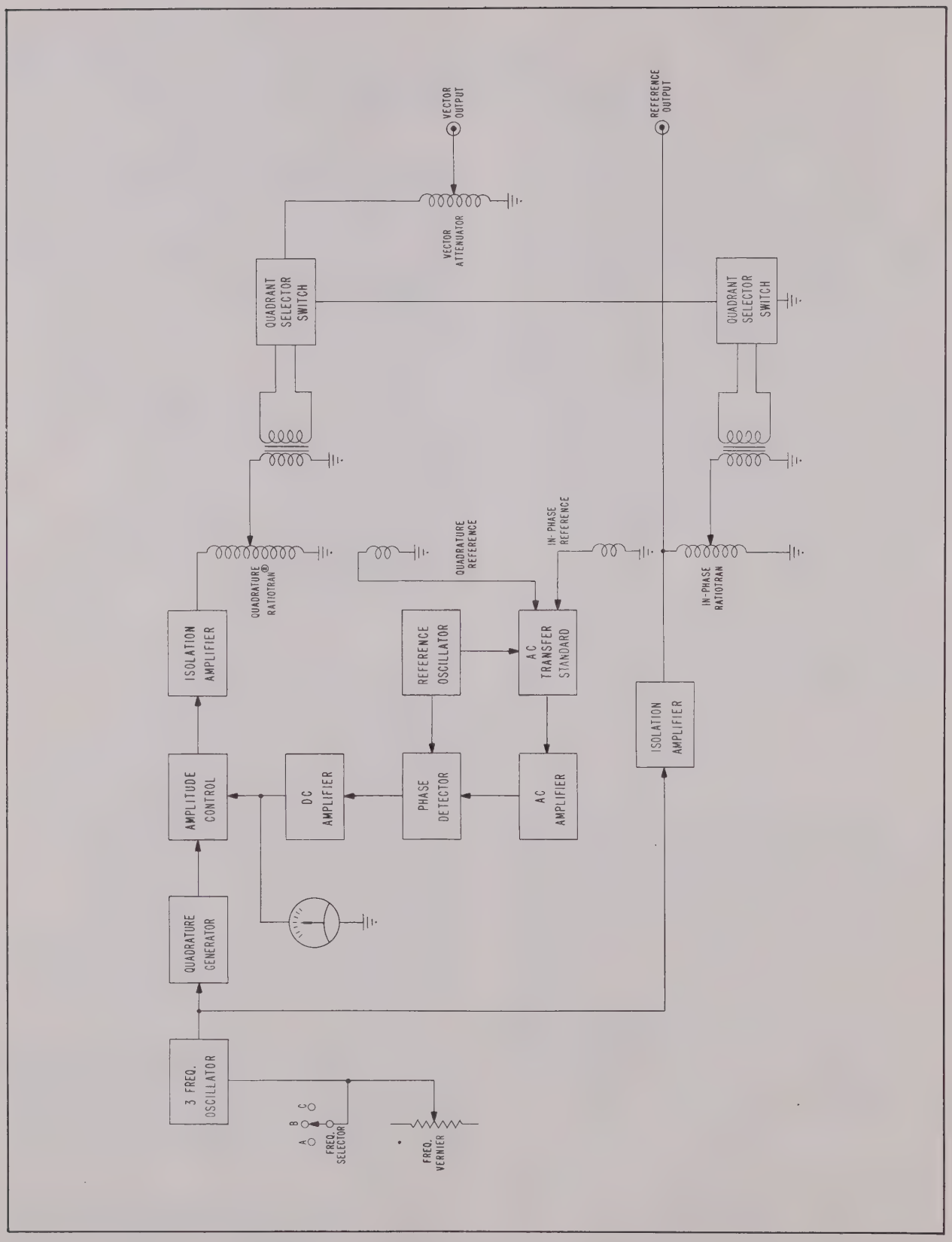


Figure 1-3. Variable Phase Standard Block Diagram

in amplitude. The difference signal, after amplification and conversion to a dc signal, corrects the amplitude of the quadrature component through the photocell circuit.

1-12. LOCAL OSCILLATOR. (See figure 1-4.) The local oscillator V1 and V2 is a Wien bridge type oscillator, with the operating frequency determined by a resistor-capacitor network Z1. One preset network is furnished with the unit, however, the unit can accommodate up to three networks. The applicable network is selected by FREQUENCY switch S1. The output of the oscillator is fed to the inphase isolation amplifier V3 and V4 through capacitor C5 and to the quadrature generator V5 and V6 through capacitor C11.

1-13. The operating frequency may be varied ±5% from the present center of the network Z1 through VERNIER resistor R2. The network also includes a vernier frequency control but the vernier control should only be used if the desired frequency cannot be obtained through the use of the VERNIER resistor R2. Resistor R14 controls the oscillator amplitude thermistor A1.

1-14. QUADRATURE GENERATOR. The quadrature voltage is generated by an operational amplifier connected as a differentiator. When the ratio of open loop gain to closed loop gain is large, the output voltage is an accurate differential of the input, multiplied by a constant "K". In this instance the D equals 0.1 and output is 0.1x (input voltage) 90 degrees. The open loop gain is 400. The closed loop gain of the amplifier is then determined by the ratio of the input impedance to the feedback impedance. The input impedance is furnished by a capacitor and the feedback impedance by a resistor, both contained in the quadrature network Z2. The potentiometer in Z2 is adjusted to a 90 degree quadrature standard, to further reduce the phase error. The 5 volt output signal of the quadrature generator is applied to the amplitude control photocell, where it is further attenuated by a factor of 2.

1-15. QUADRATURE ISOLATION AMPLIFIER. The quadrature isolation amplifier has a closed loop gain of 20, which compensates for voltage losses incurred in the quadrature generator and amplitude control section. The amplifier also eliminates loading effects on the quadrature generator.

1-16. INPHASE ISOLATION AMPLIFIER. Low phase-shift and unity gain are accomplished in the inphase isolation amplifier by the use of negative feedback. This amplifier eliminates loading effects on the oscillator.

1-17. AC TRANSFER STANDARD. The ac transfer standard consists of two 4-terminal thermistors, used in a typical ac bridge circuit. Bridge balance is obtained when the signals received from the inphase ratio transformer and the quadrature ratio transformer are equal. When the unbalanced bridge situation (previously discussed) occurs, a 7 kc error signal, proportional the amplitude error between the quadrature and the inphase signals is produced across the transformer T3, and sent to the ac amplifier.

1-18. AC AMPLIFIER. The ac amplifier is tuned to 7 kc and provides the high gain and low impedance necessary to drive the phase detector.

1-19. PHASE DETECTOR. The phase detector provides a dc error signal, which represents the phase and amplitude of the ac error signal received from the ac amplifier. Potentiometer R113 compensates for any circuit unbalance within the phase detector.

1-20. DC AMPLIFIER. The dc error signal from the phase detector is further amplified by the dc amplifier to a level needed to change the quiescent operating point of the light bulb in the amplitude control section. Light output variations proportional to the error signal, produce resistance changes in the photocell, which force the input signal to a level necessary to reduce the error signal. The remaining photocell in the amplitude control section generates a rate feedback signal which further stabilizes the quadrature amplitude control circuit.

1-21. REFERENCE OSCILLATOR. The reference oscillator is a varistor controlled Wien type bridge oscillator, which supplies a reference signal of 7 kc to the ac transfer standard bridge circuit.

1-22. POWER SUPPLY. Plate and heater power for the unit is provided by power transformer T201 (see figure 1-5). Oven voltage is supplied by T202. Both primaries are wound with two equal 115 vac windings that can be connected either in parallel for 115 vac operation or in series for 230 vac operation. Binding posts and straps are provided for a simple change-over to either voltage (see figure 1-12). The unit is normally connected for 115 vac operation using a 1.5A fuse for T201 and a 0.2A fuse for transformer T202. For 230 vac operation, the T201 fuse should be changed to one of 0.75A rating, and the transformer T202 fuse to one of 0.1A rating. Transformer T202 secondaries consist of three high voltage windings, four 6.3V heater windings, and one 36V winding. All rectifiers are of the silicon type. Transformer T202 and associated components provide 115 vac to the oven. Transformer T202 has a 115V secondary and is necessary only to permit 115/230 volt operation.

1-23. REGULATION. All but one of the dc voltages furnished by the power supplies are electronically regulated. The reference voltage is established by means of a gas diode voltage stabilizer V206 and is used to control the output of the -300 vdc supply.

1-24. HEATER SUPPLIES. To reduce the heater to cathode potentials in the power supply tubes and the VPS-1 circuitry, multiple heater sources brought to various voltage levels are required. Each heater winding is identified on the schematic with the number of the tube which it supplies. The 28 vdc supply is to provide hum-free heater power to critical circuits in the unit.

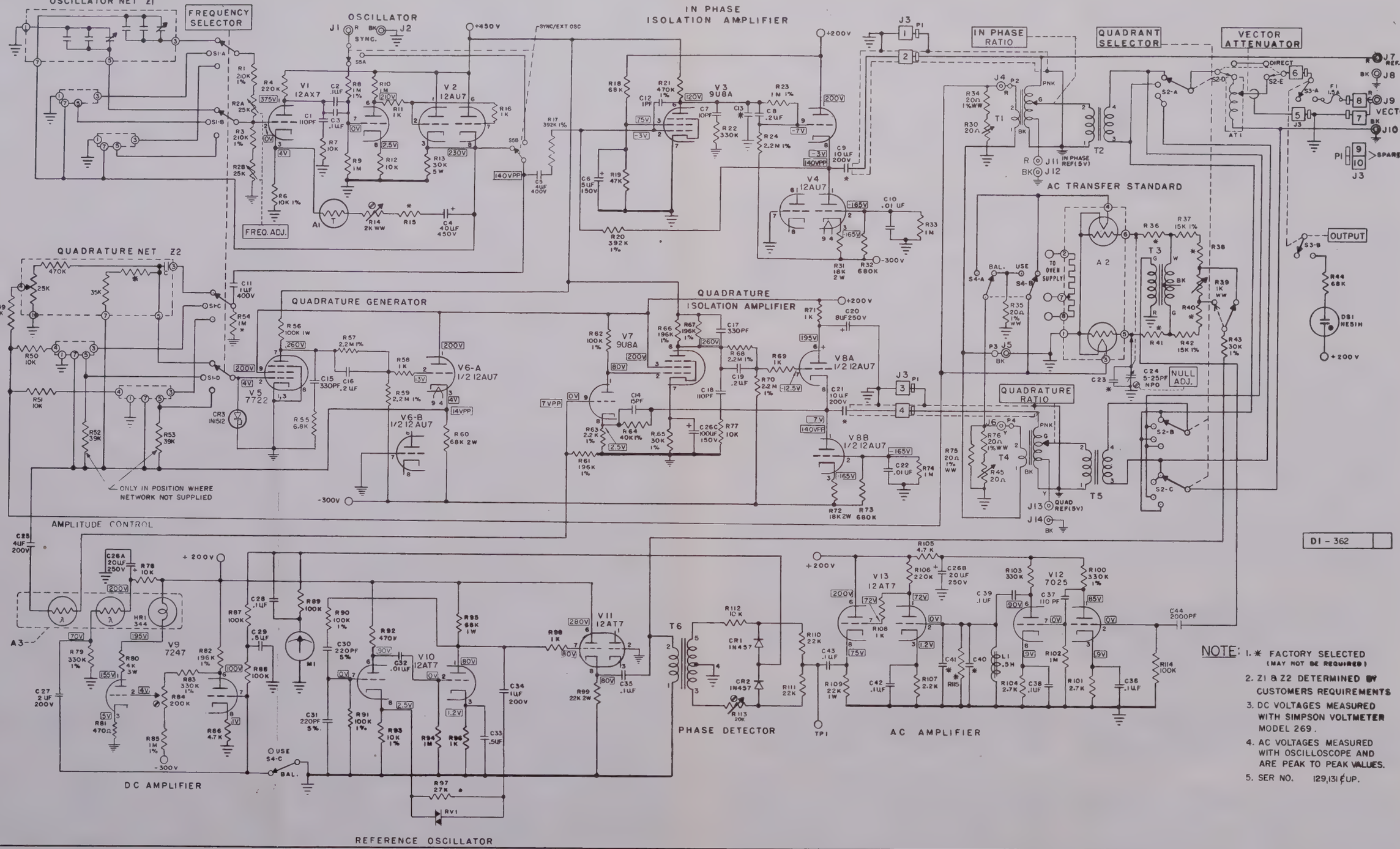
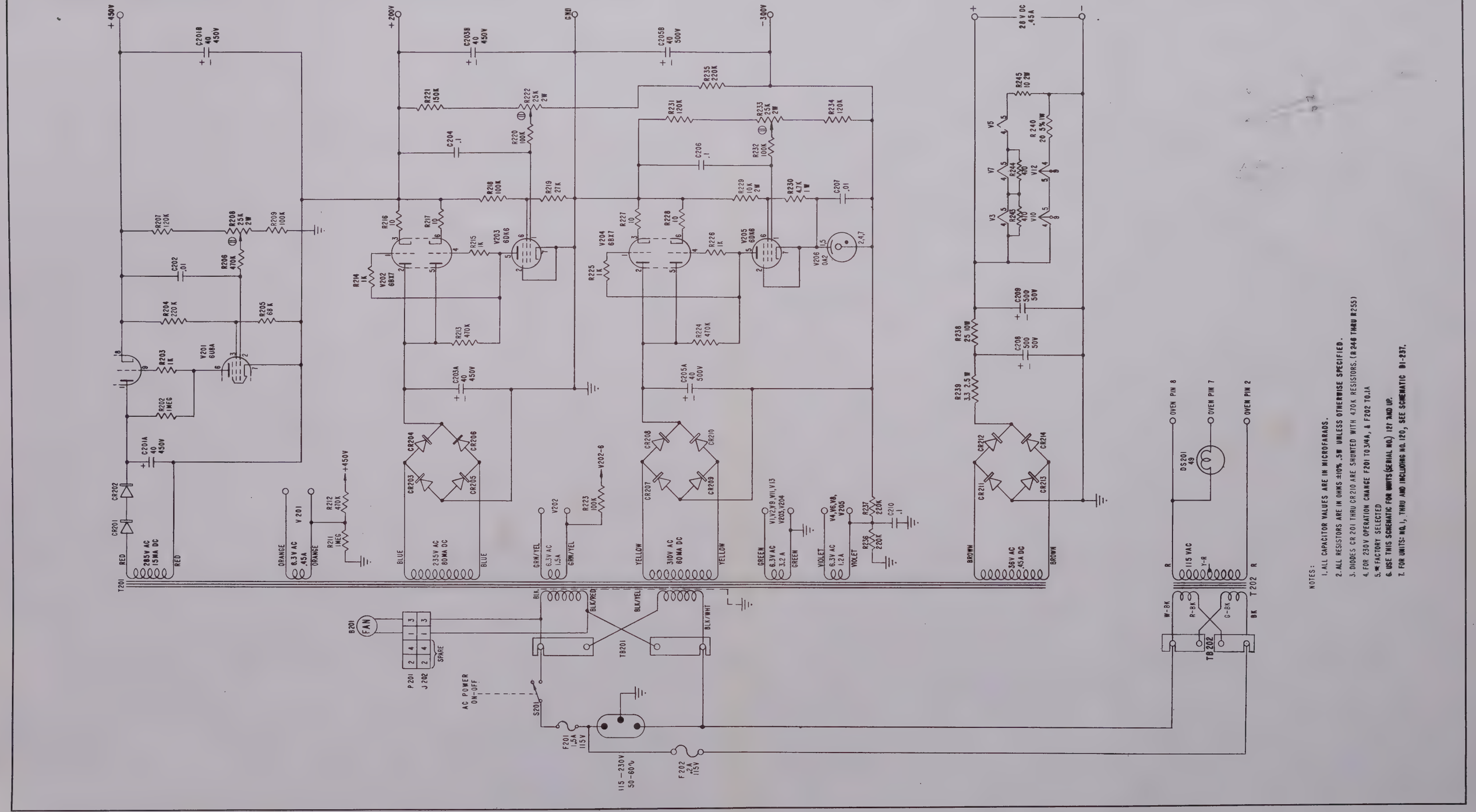


Figure 1-4. Variable Phase Standard Schematic Diagram



NOTES:

1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTORS ARE IN OHMS ±10% .5W UNLESS OTHERWISE SPECIFIED.
3. DIODES CR 201 THRU CR 210 ARE SHUNTED WITH 470K RESISTORS. (R 246 THRU R 255)
4. FOR 230 V OPERATION CHANGE F201 TO 3/4A, & F202 TO 1A
5. *FACTORY SELECTED
6. USE THIS SCHEMATIC FOR UNITS (SERIAL NO.) 127 AND UP.
7. FOR UNITS: NO. 1, THRU AND INCLUDING NO. 120, SEE SCHEMATIC D1-237.

Figure 1-5. Variable Phase Standard Power Supply Schematic Diagram

1-25. QUADRATURE STANDARD. (See figures 1-6 and 1-7.)

1-26. Each quadrature generator contains an integrating amplifier. The output from each integrating amplifier drives a phase inverting transformer. Secondary windings of the phase inverting transformers are connected so that their voltages oppose each other, the voltage difference appears at the output terminal and is fed to the null indicator.

1-27. The reference amplifier provides inphase and quadrature reference signals for the null indicator.

1-28. In operation, the two integrators are first connected in series, producing an approximate phase shift of 180 degrees. If the gain of the integrators is not unity, the difference voltage is fed to a phase sensitive null indicator with an inphase reference signal from the reference amplifier. The integrators are then adjusted to achieve a gain product of unity. A parallel connection of the integrators is then made, producing a phase shift of approximately 90 degrees per integrator. If the gain of each integrator is not equal, the difference voltage is fed to the null indicator with a quadrature reference signal; the gains are adjusted for equality. This procedure is repeated, until the correct gain is achieved in both series and parallel connections.

1-29. Upon completion of the gain adjustments, a similar procedure is performed to obtain the correct phasing. A simultaneous null exists only when the gain of the two integrating amplifiers is unity and the phase shift of each is exactly 90 degrees. One integrator is then used to produce the output quadrature vector.

1-30. NULL INDICATOR.

1-31. GENERAL PRINCIPLES. (See figure 1-8.) The emitter follower provides a one megohm input impedance to the amplifier and prevents damage to the device under test by limiting the "off-null" current. Stabilization is provided by the amplifiers. The reference transformer provides the means to sum the input signal and the reference input. These sums are rectified in the phase sensitive detector and the difference is indicated on the null meter. If the reference voltage is exactly 90 degrees out of phase with the input voltage, the rectified outputs will be equal, with a resultant meter deflection of zero.

1-32. DETAILED DESCRIPTION. (See figure 1-9.) Resistive-capacitive network R101, R102, R103, and C101 through C104 attenuate the input signal. Variable capacitors C101 and C102 are included to adjust the frequency response of the attenuator. Emitter followers Q101 and Q102 provide an input impedance of one megohm. Resistor R105 and clipping diodes CR101 and CR102 limit current to the null amplifier circuits.

1-33. Frequency switch S101 is provided to select one of three possible filters, FL100 corresponding to the frequency being used. Filters FL100 provide noise and harmonic suppression which could obscure the null. Phase correction network R169, R170, C123, C124, C125, and C134 is provided to permit operation of the unit with a frequency differing slightly from design frequency.

1-34. Transistors Q103 and Q106 are resistance-capacitance coupled amplifier-pair voltage amplifiers. Resistors R117 and R124 provide paths for a large negative dc feedback voltage, stabilizing the operating parameters of the circuit. Clamping diodes CR103 and CR104 prevent the signal from exceeding the base emitter ratings of the transistor. C113 is a peaking capacitor which improves the high frequency response of the input circuit.

1-35. The amplifier output is coupled through C119 to drive the phase detector. The voltage output of the phase detector is reduced as the quadrature or inphase component of the input signal is reduced (depending on reference phase). With a quadrature reference, the detector output will be minimum when the input signal is exactly 90 degrees out of phase with the reference. Meter M101 under these conditions indicates a null. External quadrature and inphase signals, selectable by switch S106, are supplied to reference transformer T101. Reference switch S104 is provided to select the proper secondary tap for correct signal level to the phase detector.

1-36. Power transformer T102 is connected to full-wave bridge rectifier CR114. Filtering is provided by resistor R139 and capacitors C120 and C121 and limiting by CR113. The power transformer primary is wound with two equal 115 volt windings which can be connected either in parallel for 115 volt operation, or in series for 230 volt. Binding posts and straps are provided for a simple changeover to either voltage.

1-37. PREPARATION FOR USE.

a. Remove equipment from shipping crate.

b. Check for damage that may have occurred during shipment.

c. Check that all necessary cables are contained in package. (See figure 2-1.)

d. Locate unit on a bench so that all controls are within easy reach of operator.

e. A 115 or 230 volt, 50 to 60 cycle, alternating current power source must be available at operating site.

1-38. OPERATING INSTRUCTIONS.

1-39. The following instructions are for the operation of the variable phase standard. Instructions for operating the quadrature standard and null indicator are contained in the CALIBRATION procedure, paragraph 1-49.

1-40. OPERATING CONTROLS AND INDICATORS. See figures 1-10 and 1-11 for location, identification, and function of operating controls and indicators.

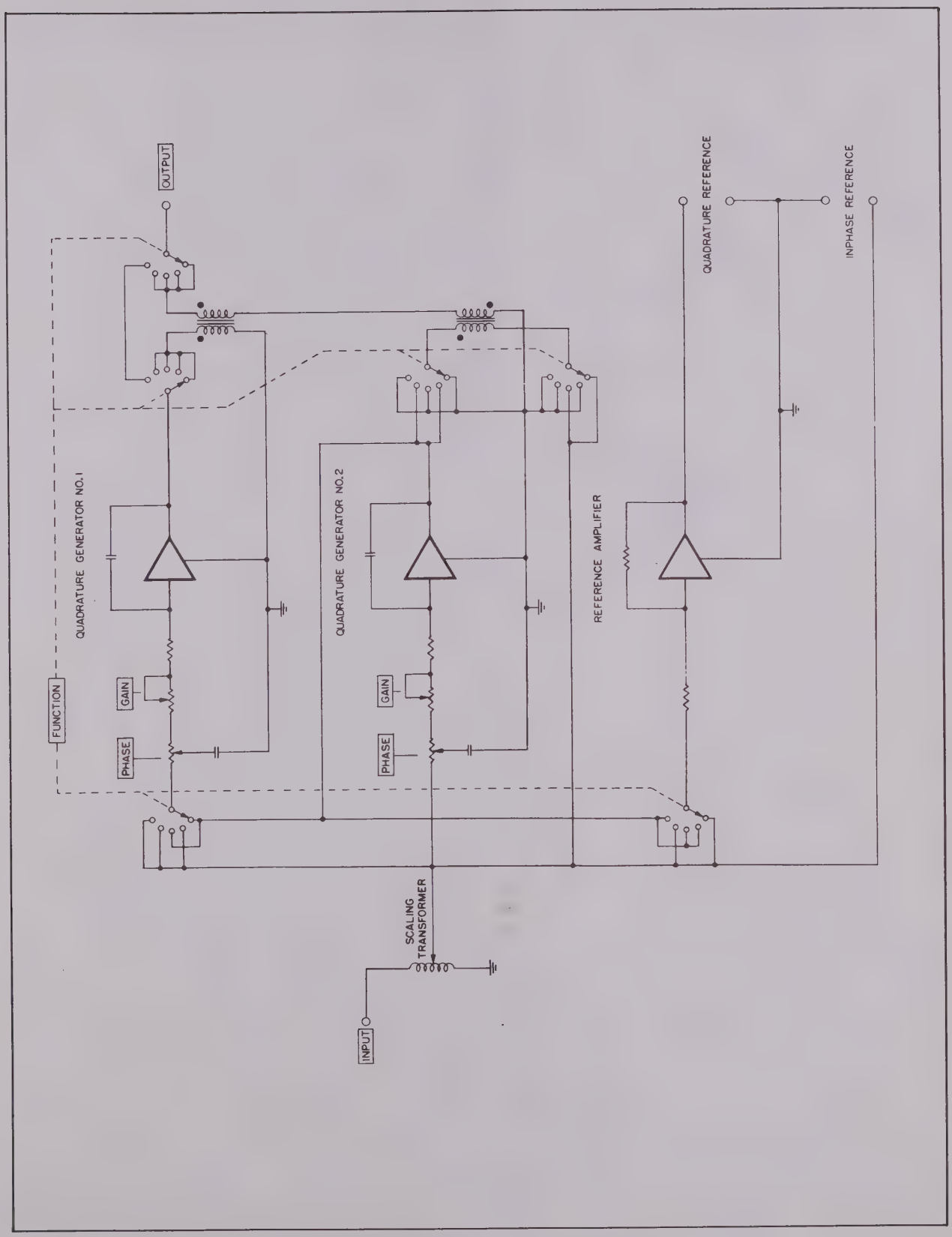
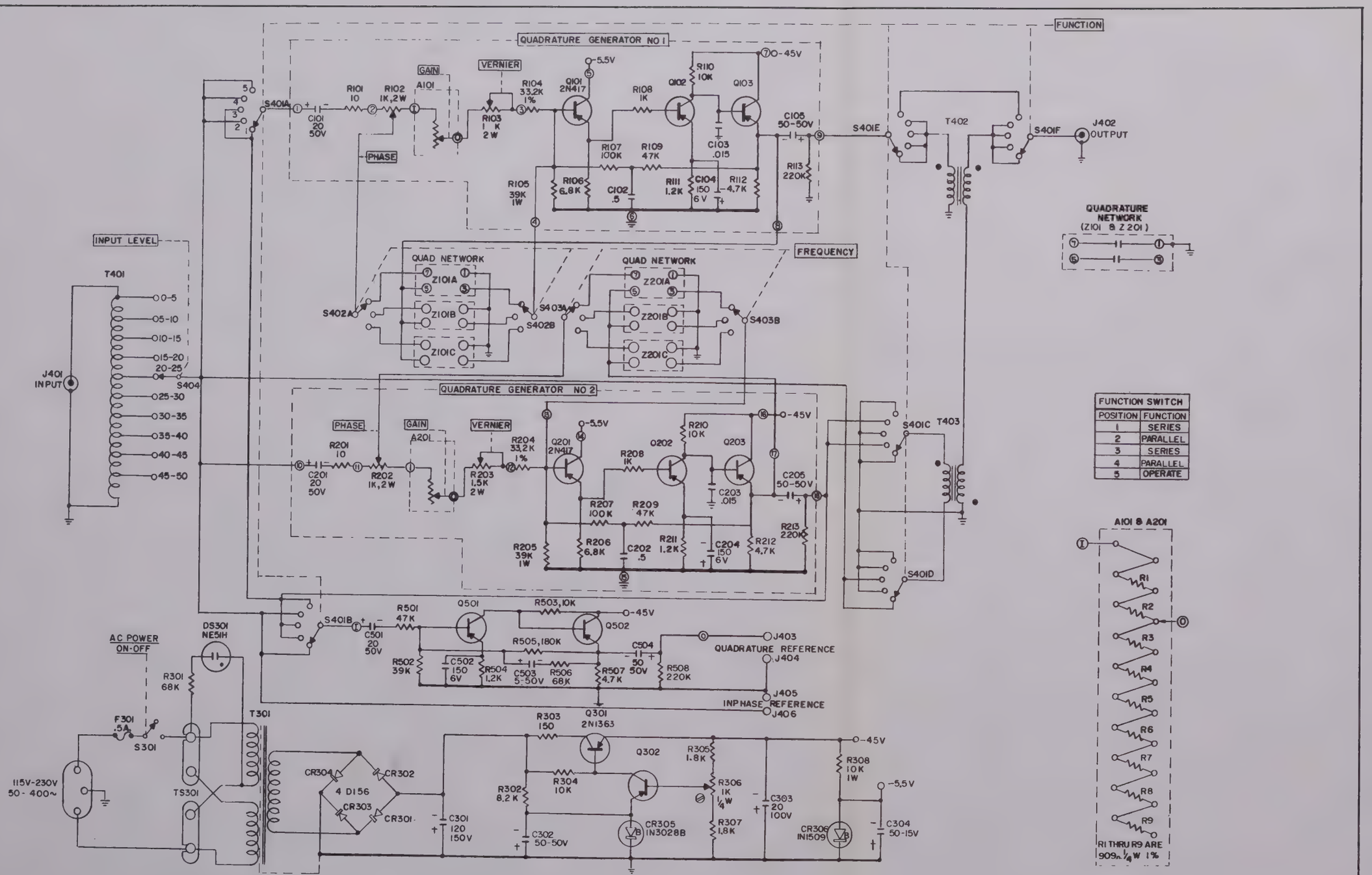


Figure 1-6. Quadrature Standard Block Diagram



NOTES–UNLESS OTHERWISE NOTED:
1 ALL CAPACITORS ARE IN MICROFARADS
2 RESISTORS ARE 1/2 WATT - 10% TOLERANCE
3 TRANSISTORS ARE EPII

Figure 1-7. Quadrature Standard Schematic Diagram

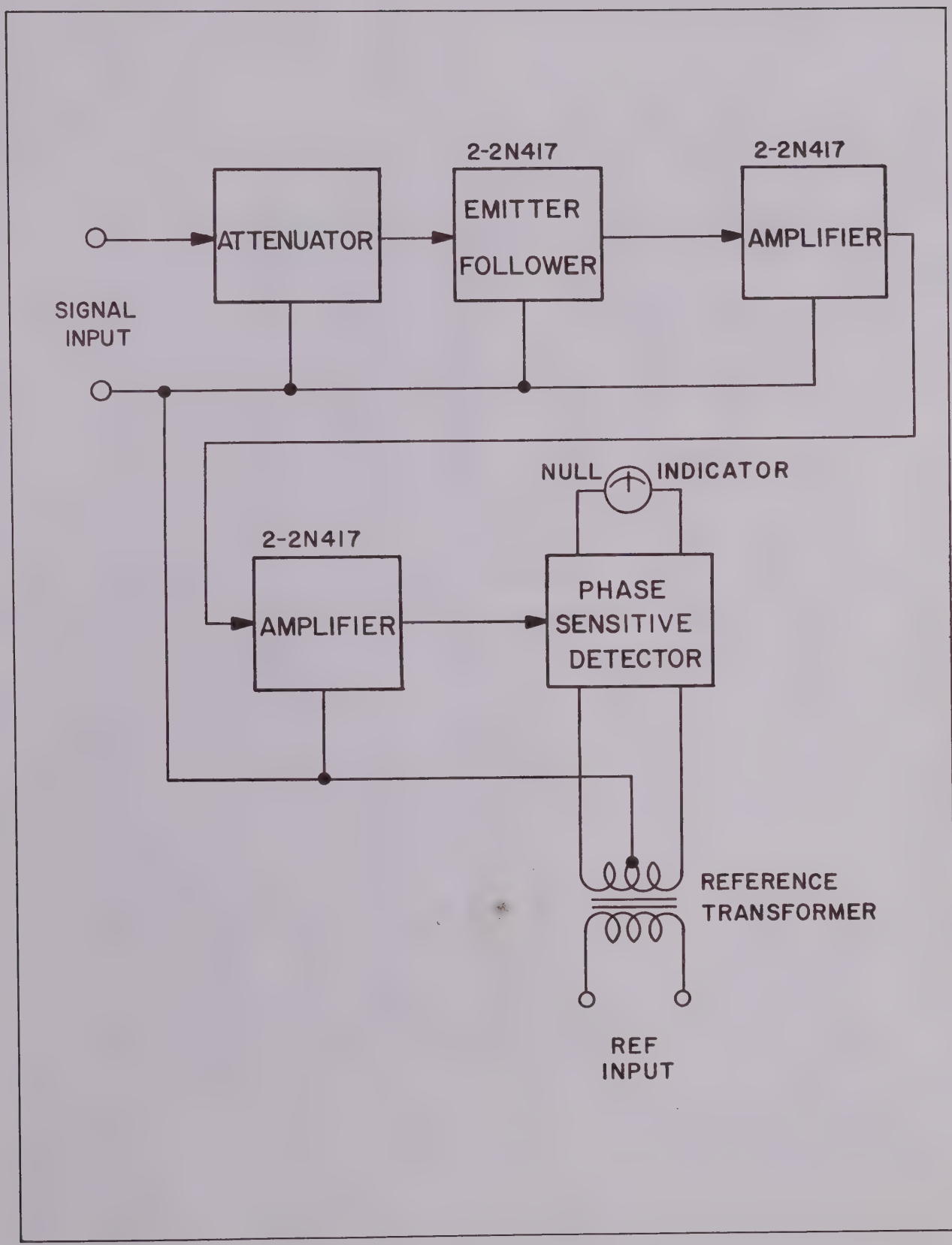
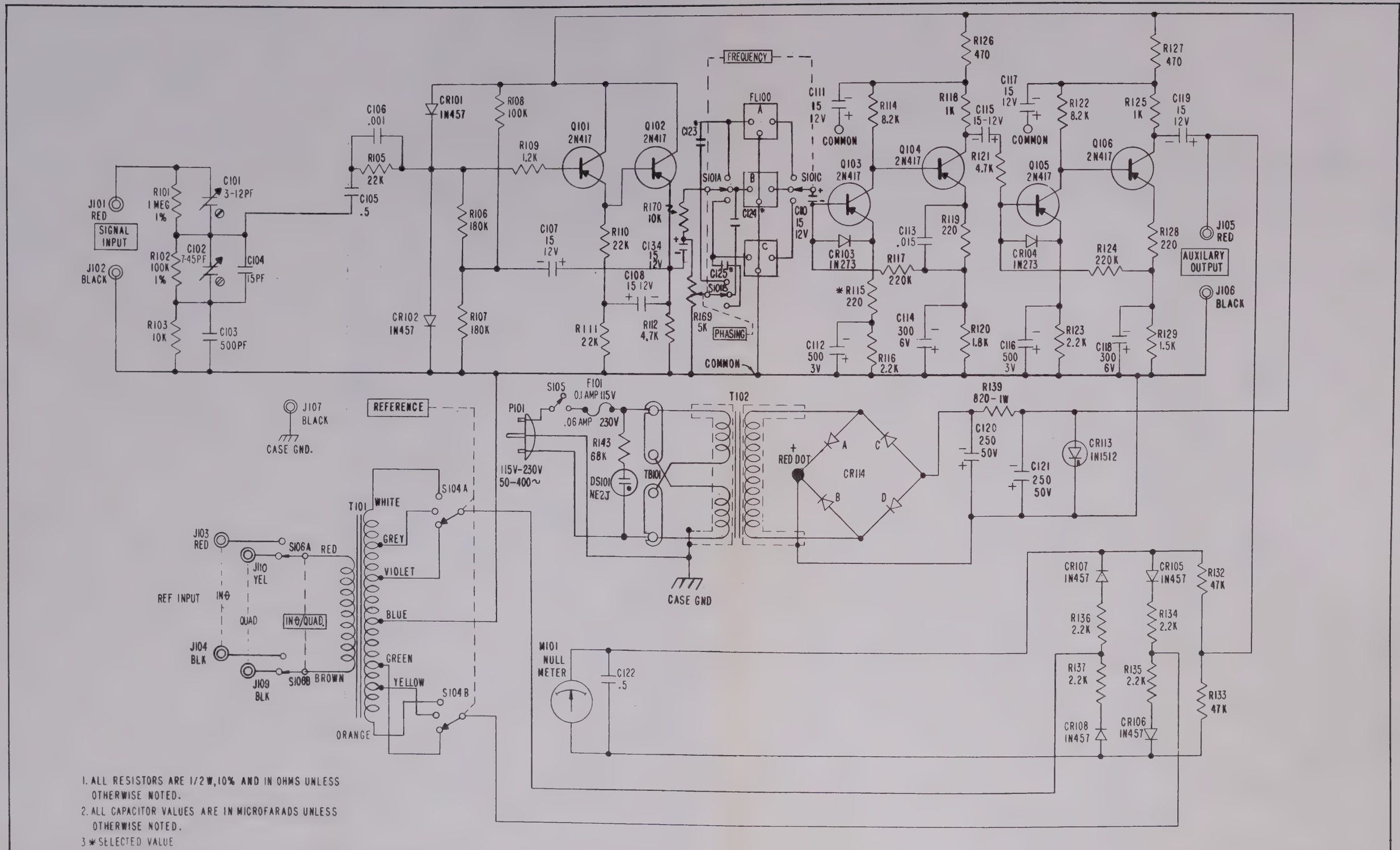
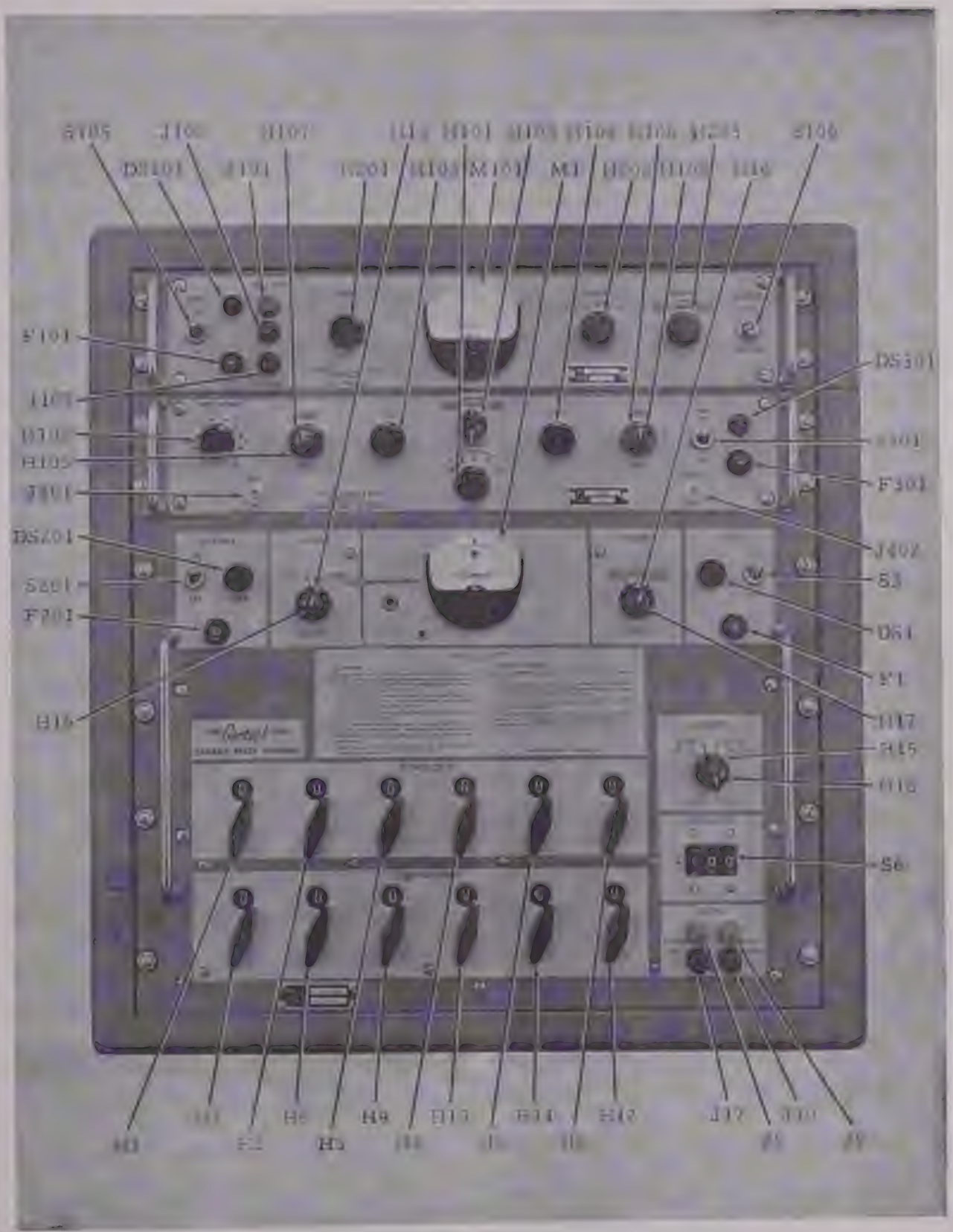


Figure 1-8. Null Indicator Block Diagram



1. ALL RESISTORS ARE 1/2W, 10% AND IN OHMS UNLESS OTHERWISE NOTED.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
3. * SELECTED VALUE

Figure 1-9. Null Indicator Schematic Diagram


S105
J106
J107
J101
J201
J102
M101
M1
S106
DS101
J103
J104
J105
J202
J203
J204
J205
J206
J207
J208
J209
J210
J211
J212
J213
J214
J215
J216
J217
J218
J219
J220
J221
J222
J223
J224
J225
J226
J227
J228
J229
J230
J231
J232
J233
J234
J235
J236
J237
J238
J239
J240
J241

REF DESIG (See figure 1-10)	NAME	FUNCTION
DS1	OUTPUT	Indicates power at variable phase standard output.
DS101	POWER ON	Indicates power on at null indicator.
DS201	OVEN	Indicates power is being supplied to oven.
DS301	POWER ON	Indicates power on at quadrature standard.
F1	OUTPUT	Output circuit overload protection.
F101	POWER	Power input overload protection.
F201	POWER	Power input overload protection.
F301	POWER	Power input overload protection.
H1 thru H6	INPHASE (COS θ)	Determines and indicates inphase component of output vector.
H7 thru H12	QUADRATURE (SIN θ)	Determines and indicates quadrature component of output vector.
H13	CALIBRATE	Permit calibration of bridge circuit prior to operation.
H14	FREQUENCY	Used to select oscillator and quadrature networks.
H15	QUADRANT	Controls polarity of inphase and quadrature components of generated vector to permit 360 degree range.
J9	VECTOR	Vector signal output.
J10	OUTPUT	Vector signal ground.
J17	OUTPUT	Reference signal ground.
J101	SIGNAL OUTPUT	Output signal terminal.
J102	SIGNAL OUTPUT	Output signal terminal.
J107	CASE GND	Ground terminal.
J401	INPUT	Terminal for signal source.
J402	OUTPUT	Provides output signal to null indicator and 90 degree signal after calibration.
M1	Meter	Indicates null condition.
M101	Meter	Indicates null condition.
S3	OUTPUT	On-off switch for variable phase.
S6	ATTENUATOR	Permits attenuation of generated vector in steps of 0.05 volt, when knob H18 in the ATTEN position. Attenuator read-out is in ratio from 0.000 to 1.000.
S105	POWER	Power on-off switch for null indicator.
S106	REFERENCE	Selects inphase and quadrature signals.

Figure 1-11. Table of Controls and Indicators (Sheet 1 of 2)

REF DESIG (See figure 1-10)	NAME	FUNCTION
S201	AC POWER	On-off switch for variable phase standard.
S301	POWER	On-off switch for quadrature standard.
H16	BALANCE	Used to balance the inphase and quadrature component amplitudes prior to operation.
H17	VERNIER	Used to adjust output frequency ±5% from design center.
H18	ATTEN-DIRECT	Permit generated vector to by-pass attenuator for full 50 volt output.
H101	FUNCTION	Switches circuitry for various calibration procedures.
H102	INPUT VOLTAGE	To set the input signal to proper level.
H103	PHASE	To adjust phasing of integrator.
H104	PHASE	To adjust phasing of integrator.
H105	GAIN	Coarse adjust for integrator for unity gain.
H106	GAIN	Coarse adjust for integrator for unity gain.
H107	GAIN VERNIER	Fine adjust for integrator for unity gain.
H108	GAIN VERNIER	Fine adjust for integrator for unity gain.
H109	FREQUENCY	Select proper network for input frequency.
H201	PHASING	To adjust phasing.
H202	REFERENCE	Select proper reference signal level.
H203	FREQUENCY	Select proper network for input frequency.
J8	REFERENCE OUTPUT	Output reference voltage terminal.

Figure 1-11. Table of Controls and Indicators (Sheet 2 of 2)

1-41. PRELIMINARY ADJUSTMENTS AND CONTROL SETTINGS.

a. Check that terminal board TB201 and TB202 is properly connected for the power source being used. (See figure 1-12.)

NOTE

The unit, as shipped from the factory, is wired for 115 vac operation.

b. Check that proper size fuses F201 and F202 are installed.

c. Set knobs and switches to the position indicated in figure 1-13.

d. Connect unit to the power source. OVEN lamp DS201, figure 1-10, must light.

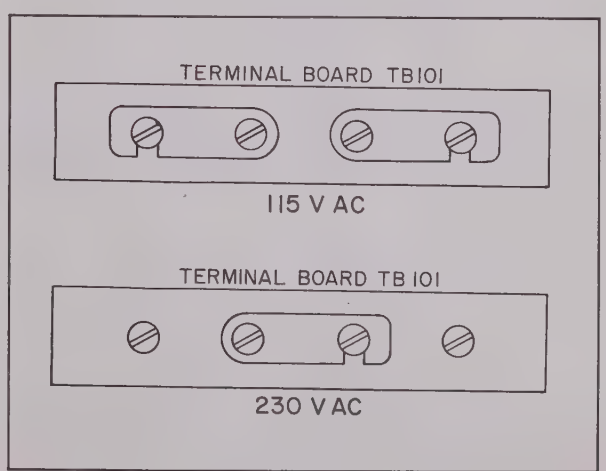


Figure 1-12. Terminal Board Connections

REF DESIG	POSITION
H1 thru H12	Indicate 0
H13	BALANCE
H14	400
S3	OFF
S106	OFF
S201	OFF
S301	OFF

Figure 1-13. Preparation Control Settings

NOTE

The internal oven, containing temperature sensitive elements is always energized when the power cord is connected to the line. Allow 2 hours warm-up for the oven.

e. After unit has been connected to the power source for one hour, place switch S201 in the ON position. Allow 1 hour for warm-up, then proceed with adjustments.

f. Adjust BALANCE knob H16 for center scale indication on meter M1. Allow time for meter stabilization.

g. Set CALIBRATE knob H13 to OPERATE position. Allow time for meter stabilization.

h. Connect a high gain oscilloscope to jack TP1; connect oscilloscope ground to post J10. Adjust capacitor C24 for minimum signal on oscilloscope.

1-42. OPERATION.

a. Set the QUADRANT switch knob H15 to the position that includes the desired angle.

b. Referring to trigonometric tables (use at least six place tables). Set the INPHASE (COS θ) knobs H1 through H6 to cosine of the desired angle and the QUADRATURE (SIN θ) knobs H7 through H12 to the sine of the desired angle.

c. The vector is now available at posts J9 and J10, when OUTPUT switch S3 is in the ON position.

NOTE

The maximum amplitude of the vector is 50 volts. Amplitude may be reduced by adjusting the ATTENUATOR control switch S6. The attenuator may be by-passed by placing the ATTEN-DIRECT switch knob H18 in the DIRECT position.

1-43. SHUTDOWN.

a. Place controls in position indicated in figure 1-12.

b. Remove and stow cable assemblies.

NOTE

Whenever possible, leave unit connected to power source.

1-44. MAINTENANCE INSTRUCTIONS.

1-45. GENERAL. Paragraphs 1-42 through 1-44 contain the routine maintenance required on the variable phase standard. In addition, the calibration procedure outlined in paragraph 1-45 must be performed as scheduled. Remove the three units from cabinet and perform the following maintenance every three months.

1-46. CLEANING AND INSPECTION. After removing from unit, clean and inspect components as follows:

a. Vacuum all dirt and dust from the units.

b. Inspect for loose components, screws, and nuts.

c. Inspect switch contacts for dirt, dust, and evidence of arcing. Clean contacts, as required, using isopropyl alcohol, Federal Specification TT-I-735.

d. Inspect electrical components and wiring for discoloration, swelling, leaking potting compound, brittleness of insulation, and other evidence of overheating.

e. Inspect cables for exposed wire. Check that plugs make positive contact when inserted into receptacles.

1-47. REPAIR OR REPLACEMENT. Replace parts found to be defective during inspection observing the following:

a. Refer to schematic diagrams, figures 1-4, 1-7, and 1-9, for wiring of part.

b. Perform soldering in accordance with Military Standard MIL-STD-440 using Federal Specification QQ-S-571.

c. After replacement of parts, unit must be calibrated as instructed in paragraph 1-47.

1-48. TROUBLE SHOOTING. Locate malfunctioning components as follows:

a. Use block diagrams, figures 1-3, 1-5, and 1-8, and schematic diagrams, figures 1-4, 1-6, 1-7, and 1-9, to isolate trouble.

b. Check voltage at locations indicated on the wiring diagrams.

c. Make continuity and resistance checks as required.

d. Check tubes in a standard tube tester.

e. See figure 1-14 for common troubles, probable cause, and remedial action.

TROUBLE	PROBABLE CAUSE	REMEDY
No output voltage	Blown fuse	Check and replace fuses as required.
	No input voltage	Check input power source, plug, and cable.
	Dirty or damaged switch	Clean contacts. Replace switch.
	Defective tubes	Check and replace tubes as necessary.
	Defective wiring	Make continuity check and resolder or replace as required.
Erratic output	Damaged or loose interconnection	Tighten connection. Replace damage part.
	Damaged tube	Check and replace tubes as required.
	Intermittent shorts or opens	Locate and repair defective part or wire.

Figure 1-14. Trouble Shooting Information

1-49. CALIBRATION.

1-50. GENERAL. Calibrate the angular accuracy of the variable phase standard every 30 days during the first six months of use and every 90 days thereafter. The angular accuracy is dependent on the generation of an accurate quadrature signal and the amplitude equality between the quadrature and inphase signals. All necessary test equipment is furnished with the unit.

NOTE

Whenever angular accuracy of 0.01 percent is required, the unit should be calibrated.

1-51. PRELIMINARY ADJUSTMENTS AND CONTROL SETTINGS. Install cables W2 and W3 as shown in figure 1-15. Check that cable assemblies W4 and W5 are installed as shown in figure 1-16. Adjust and set controls as follows:

a. Place POWER switches S105, S201, and S301, figure 1-10, in the ON position. Allow 60 minutes for equipment warm-up.

b. Place FREQUENCY switch knobs H14, H109, and H203 to the same indication.

c. Set INPHASE (COS θ) and QUADRATURE (SIN θ) control knobs H1 through H12 to indicate zero.

d. Place CALIBRATE switch knob H13 to BALANCE position and adjust BALANCE control knob H16 for center scale indication on meter M1.

e. Place ATTEN-DIRECT switch knob H18 in the DIRECT position.

f. Set INPUT VOLTAGE switch knob H102 to 50.

g. Place FUNCTION switch knob H101 in the OPR position.

h. Set REFERENCE level switch knob H202 to the 5-25V position.

i. Place REFERENCE switch S106 in the INPHASE position.

j. Set INPHASE (COS θ) control knobs H1 through H6 to indicate .000030.

k. Check that null meter M101 deflects approximately full scale.

l. Place REFERENCE selector switch S106 in the QUADRATURE position.

m. Adjust PHASING control knob H201 for null indication on meter M101.

n. Install cables W1 and W2 as shown in figure 1-17.

o. Set INPHASE (COS θ) and QUADRATURE control knobs H1 through H12, figure 1-10, to indicate zero.

p. Place QUADRANT switch knob H15 in the 0°-90° position.

q. Place FUNCTION switch knob H101 in the CAL 1 position.

r. Simultaneously adjust GAIN control knobs H105 and H106 in the same direction until null indication is obtained on meter M101.

s. Set FUNCTION switch knob H101 in the CAL 2 position.

t. Simultaneously adjust GAIN control knobs H105 and H106 in opposite directions until null indication is obtained on meter M101.

u. Repeat steps q through t until meter M101 remains at null when FUNCTION switch knob H101 is alternately positioned to CAL 1 and CAL 2 positions.

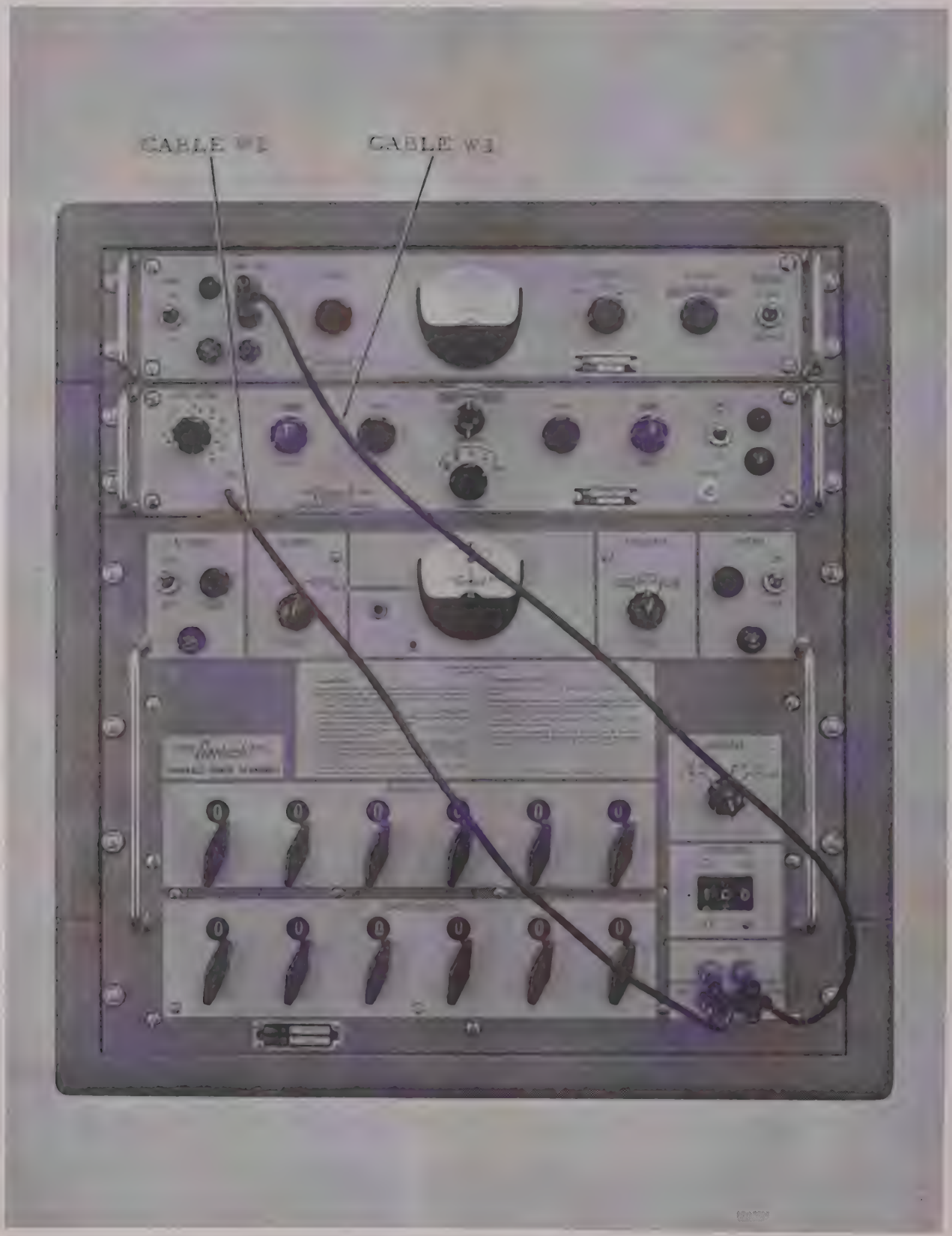


Figure 1-15. Cable Installation

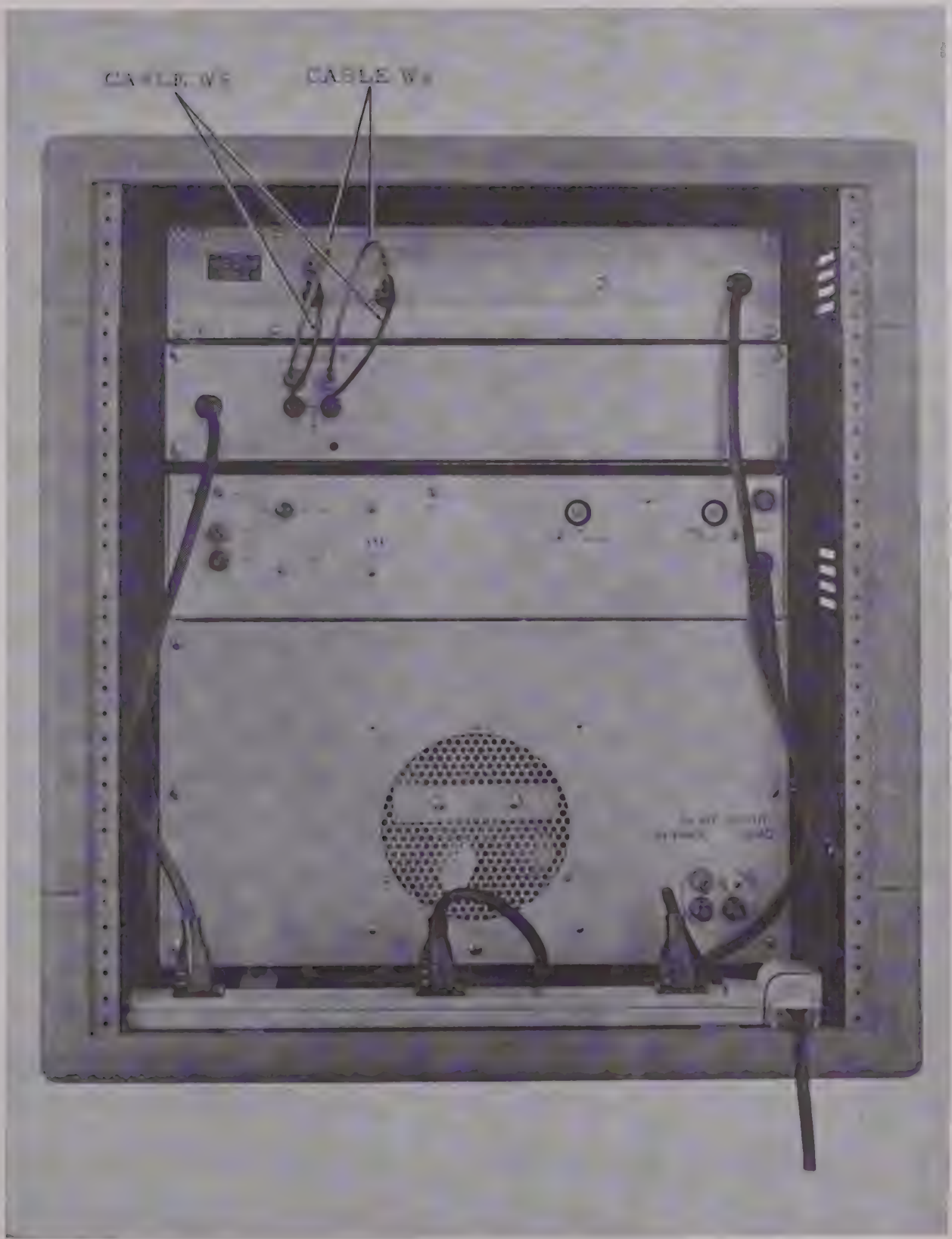


Figure 1-16. Cable Installation

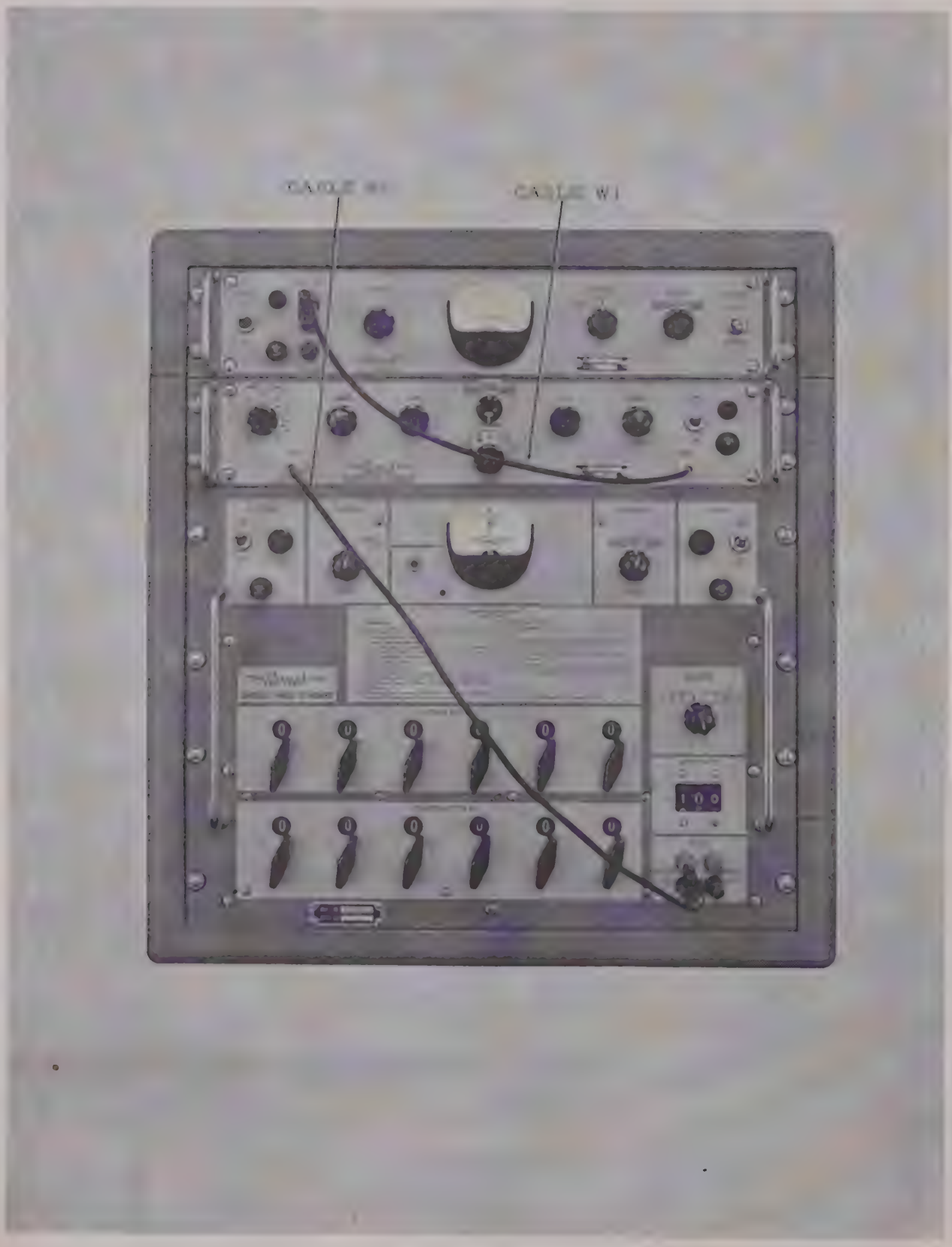


Figure 1-17. Cable Installation

v. Place FUNCTION switch knob H101 in the CAL 3 position.

w. Simultaneously adjust PHASE control knobs H103 and H104 in the same direction until null indication is obtained on meter M101.

x. Place FUNCTION switch knob H101 in the CAL 4 position.

y. Simultaneously adjust PHASE control knobs H103 and H104 in opposite directions until null indication is obtained on meter M101.

z. Repeat steps v through y until meter M101 remains at null when FUNCTION switch knob H101 is alternately positioned to CAL 3 and CAL 4 position.

aa. Repeat calibration procedure as necessary until meter M101 remains at null when FUNCTION switch knob H101 is placed in each of the four CAL positions.

1-52. QUADRATURE ANGLE ACCURACY TEST. After unit has been calibrated, test quadrature angle accuracy as follows:

a. Interconnect equipment as shown in figure 1-18.

CAUTION

Make certain that ground side (marked GND) of cable plugs are not connected to the null indicator.

b. Place FUNCTION switch knob H101 in the OPR position.

c. Place REFERENCE switch S106 in the QUADRATURE position.

d. Adjust QUADRATURE (SIN θ) switch knobs H7 through H12 to obtain null indication on meter M101.

e. Place REFERENCE switch S106 in the INPHASE position.

f. Adjust INPHASE (COS θ) switch knobs H1 through H7 to obtain null indication on meter M101. If required, turn QUADRANT switch knob H15 to 90°-180° position.

g. Check that INPHASE (COS θ) ratio is .000017 or less. If ratio exceeds this value, adjust variable phase standard A101 as follows:

h. Slide variable phase standard A101 forward until quadrature network screwdriver adjustment is accessible (see figure 1-19).

i. Set INPHASE (COS θ) switch knobs H1 through H6 to .000000.

j. Adjust the screwdriver adjustment of the applicable network as required to obtain null indication on meter M101.

1-53. AMPLITUDE EQUALITY TEST. After quadrature angle accuracy has been tested, test unit for amplitude equality as follows:

a. Disconnect all front panel interconnecting cables.

b. Place CALIBRATE switch knob H13 in the BALANCE position.

c. Turn FREQUENCY switch knob H14 away from the center position.

d. Remove back dust cover from variable phase standard.

e. Remove the bracket which secures the quadrature network in place. (See figure 1-19 for location of network.)

f. Replace quadrature network with quadrature test network A401, figure 2-1.

g. Place FREQUENCY switch knob H17 to the center position (normally the 400 cps position).

h. Place QUADRANT switch knob H15 in the 90°-180° position.

i. Interconnect equipment as shown in figure 1-15.

j. Place REFERENCE switch S1-6, figure 1-10, in the INPHASE position.

k. Place FUNCTION switch knob H101 in the OPR position.

l. Adjust BALANCE control knob H16 for null indication on meter M1.

m. Place CALIBRATE switch knob H13 to the OPERATE position.

n. Set INPHASE (COS θ) control knobs H1 through H6 to indicate .100000.

o. Adjust QUADRATURE (SIN θ) control knobs H7 through H12 (approximately .100000) to obtain null indication on meter M101.

NOTE

Allow approximately one minute for stabilization.

p. Check that null occurs with QUADRATURE (SIN θ) control knobs H7 through H12 set at .100000 ±.000010. Because of circuit noise, the null may be obscured. Use an average reading if ratio exceeds this limit, adjust amplitude adjustment as follows. (See figure 1-18.)

q. Slide variable phase standard A101 until the amplitude adjustment resistors are accessible (see figure 1-19).

r. Set QUADRATURE (SIN θ) control knobs H7 through H12 to indicate .100000.

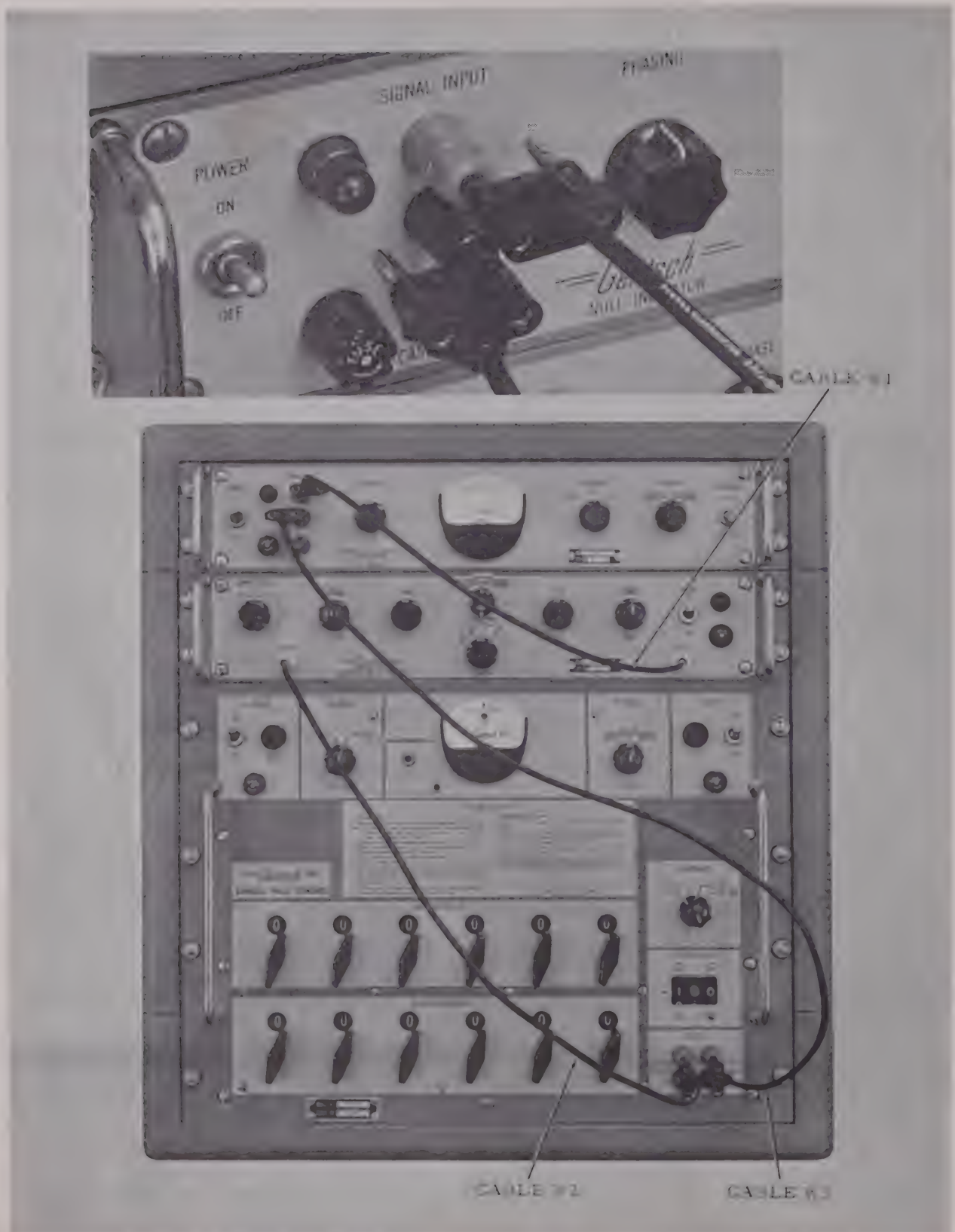


Figure 1-18. Cable Installation

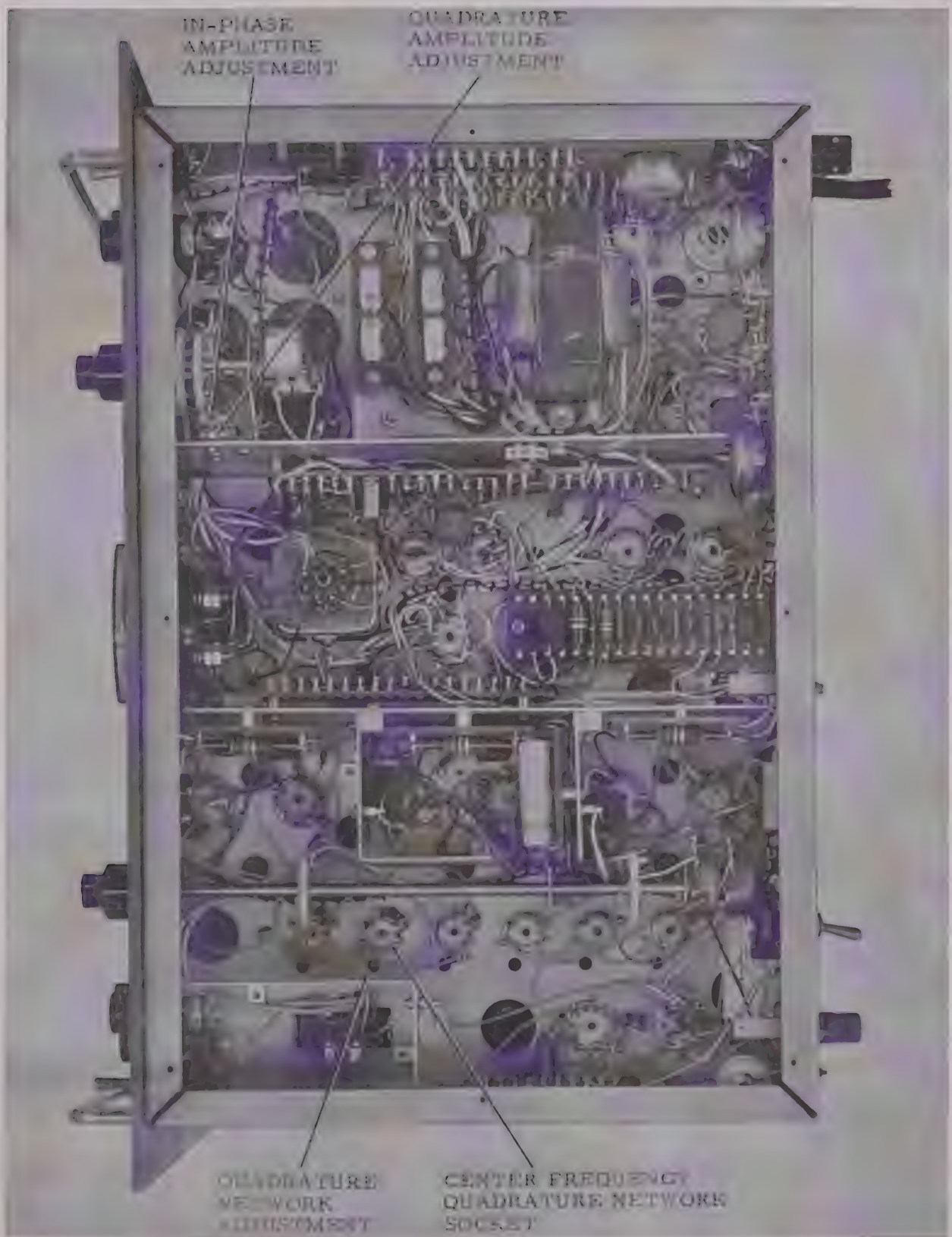


Figure 1-19. Quadrature Network Adjustment

s. Adjust quadrature and inphase amplitude adjustments as required to obtain null indication on meter M101.

t. Place CALIBRATE switch knob H13 to the BALANCE position.

u. Check that meter M1 indicates null. If required, readjust BALANCE control knob H16 to obtain null indication.

v. Repeat steps m through u as required.

w. Place CALIBRATE switch knob H13 to the BALANCE position.

x. Turn FREQUENCY switch knob H14 away from center position.

y. Replace quadrature test network with the operating quadrature network.

z. Replace network holding bracket and dust covers. Install variable phase standard in case.

SECTION II
PARTS BREAKDOWN

2-1. GENERAL.

2-2. This section lists and illustrates parts for the three units of the variable phase standard. Figure 2-1 locates the major components and is keyed to parts lists and illustrations containing the detail parts.

2-3. IDENTIFYING PARTS.

2-4. WHEN THE REFERENCE DESIGNATION IS NOT KNOWN. Refer to the illustration of the unit or assembly in which the part is used. Locate the part in the illustration and note the reference designation assigned to the part. Refer to the reference designation in the parts list accompanying the illustration. The columns following the reference designation give the part number and description.

2-5. WHEN THE REFERENCE DESIGNATION IS KNOWN. Refer to the parts list of the unit and locate the reference designation. Note the figure number which is shown opposite the reference designation. Turn to the figure indicated and locate the reference designation.

2-6. VENDOR CODES.

2-7. The following vendor code numbers are used in parts list to identify the manufacturer of the part.

CODE	NAME AND ADDRESS
00656	Aerqvox Corp. New Bedford, Mass.
02777	Hopkins Engineering Co. San Fernando, Calif.
03614	Bussmann Fuse Division of McGraw-Edison Co. Los Angeles, Calif.
04061	Allen-Bradley Co. Chicago, Ill.
04387	Dalohm Dale Electronics, Inc. Pacific Division Burbank, Calif.
05571	Sprague Electric Co. Pacific Division Los Angeles, Calif.
05625	Barber-Coleman Co. Pasadena, Calif.
08806	General Electric Miniature Lamp Department of Lamp Division of Consumer Products Group Cleveland, Ohio
09023	Cornell-Dubilier Electric Corp. Electrolytics and Paper Tubular Division Sanford, N.C.
11350	Penn Resistor Corp. Lansdale, Pa.
12060	Diodes, Inc. Canoga Park, Calif.
12065	Transition Electron Corp. East Boston, Mass.
46859	Philco Corp. Philadelphia, Pa.
49956	Raytheon Co. Lexington, Mass.
58474	Superior Electric Co. Bristol, Conn.
70903	Belden Manufacturing Co. Chicago, Ill.
71590	Centralab, Division of Globe-Union, Inc. Milwaukee, Wis.
71700	Cornish Wire Co. New York, N.Y.
71785	Cinch Manufacturing Co. Division of United-Carr Fastener Corp. Chicago, Ill.
72136	Electro Motive Manufacturing Co. Willimantic, Conn.
72619	Dialight Corp. Brooklyn, N.Y.
72819	Globar, Division of Carborundum Co. Niagara Falls, N.Y.
72982	Erie Resistor Corp. Erie, Pa.
73293	Hughes Products, Division of Hughes Aircraft Co. Newport Beach, Calif.
73559	Carling Electric, Inc. Hartford, Conn.
74970	Johnson, E. F., Co. Waseca, Minn.

CODE	NAME AND ADDRESS
75042	International Resistance Co. Philadelphia, Pa.
75173	Jones, Howard B. Division of Cinch Mfg. Corp. Chicago, Ill.
75376	Kurz-Kasch Chicago, Ill.
75915	Littlefuse, Inc. Des Plaines, Ill.
76487	Millen James Manufacturing Co., Inc. Malden, Mass.
80211	Motorola, Inc. Chicago, Ill.
80294	Bourns Laboratories, Inc. Riverside, Calif.
81095	Triad Transformer Corp. Venice, Calif.
81483	International Rectifier Corp. El Segundo, Calif.
83777	Model Engineering and Manufacturing, Inc. Huntington, Ind.
84411	Good-All Electric Manufacturing Co. Ogallala, Nebr.
84970	Sarkes Tarzian, Inc. Bloomington, Ind.
87034	Marco Industries Co. Anaheim, Calif.
88869	Gertsch Products, Inc. Los Angeles, Calif.
89536	Fluke, John, Manufacturing Co., Inc. Seattle, Wash.
93332	Sylvania Electric Products, Inc. Semiconductor Products Division Woburn, Mass.
94154	Tung-Sol Electric, Inc. Newark, N.J.
95691	Arrow Hart and Hegeman Electric Co. Los Angeles, Calif.
96214	Texas Instruments, Inc. Dallas, Texas
99942	Hoffman Electronic Corp. Semiconductor Division El Monte, Calif.

KEY TO FIGURE 2-1

REF DESIG	DESCRIPTION	PARTS LIST NO.	FIGURE NUMBER
A101	Variable Phase Standard Model VPS-1	1	2-2 thru 2-11
A201	Quadrature Standard Model QS-1	2	2-12, 2-13
A301	Null Indicator Model NI-4	3	2-14, 2-15
A401	Test Network Part No. AA947		
W1	Cable Assembly		
W2	Cable Assembly		
W3	Cable Assembly		

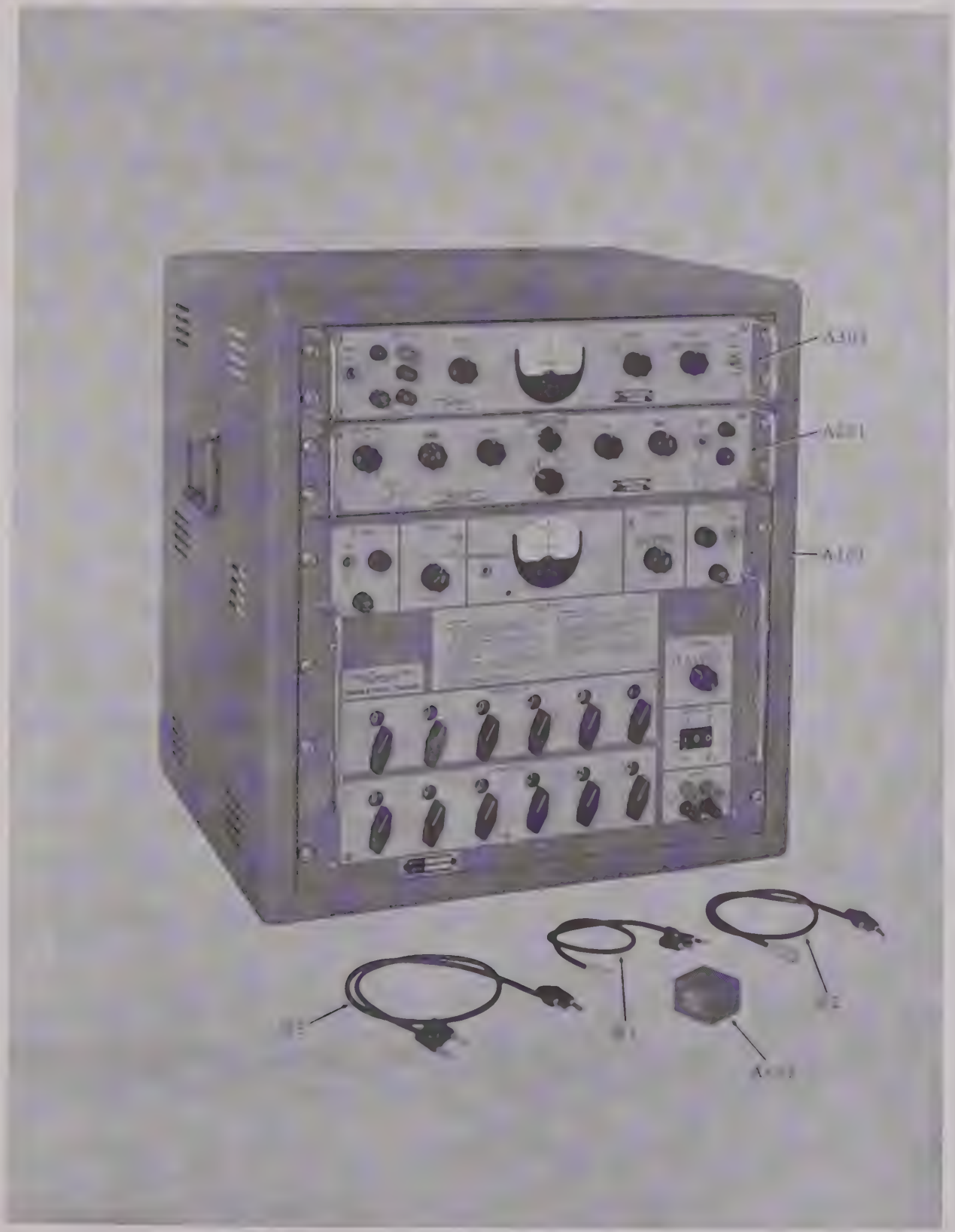


Figure 2-1. Variable Phase Standard Model VPS-1/QS-1/NI-4

Parts List No. 1. Variable Phase Standard Model VPS-1

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
A1	2-4	THERMISTOR ASSY	88869	AA503
A2	2-5	THERMAL SET ASSY	88869	AA814
A3	2-5	PHOTOCELL ASSY	88869	AA505
A101	2-5	TERMINAL BOARD ASSY, Rectifier (See figure 2-10)	88869	AA486
A102	2-5	TERMINAL BOARD ASSY, DC amplifier (See figure 2-10)	88869	AA485
A103	2-5	TERMINAL BOARD ASSY, Regulated (See figure 2-9)	88869	TB5
A104	2-5	TERMINAL BOARD ASSY, Reference oscillator (See figure 2-9)	88869	AA489
A105	2-5	TERMINAL BOARD ASSY, Inphase amplifier input (See figure 2-7)	88869	AA493
A106	2-5	TERMINAL BOARD ASSY, Inphase amplifier output (See figure 2-7)	88869	AA491
A107	2-5	TERMINAL BOARD ASSY, Quadrature amplifier output (See figure 2-7)	88869	AA513
A108	2-5	TERMINAL BOARD ASSY, Quadrature generator (See figure 2-7)	88869	AA492
A109	2-5	TERMINAL BOARD ASSY, Signal oscillator (See figure 2-8)	88869	AA494
A110	2-5	TERMINAL BOARD ASSY, Phase detector (See figure 2-4)	88869	AA488
A111	2-5	TERMINAL BOARD ASSY, Quadrature amplifier input (See figure 2-8)	88869	AA514
A112	2-5	TERMINAL BOARD ASSY, AC amplifier (See figure 2-7)	88869	AA487
AT1		ATTENUATOR ASSY (See S6 and T7)		
B201	2-3	MOTOR, Fan	05624	DYAB569-116
C1	2-8	CAPACITOR, Mica, 110 pf	72136	DM15E111J
C2	2-8	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C3	2-8	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C4	2-4	CAPACITOR, Electrolytic, 40 uf, 450 v	05571	TVA1712
C5	2-4	CAPACITOR, Plastic, 4 uf, 400 v	02777	4P4M
C6	2-7	CAPACITOR, Electrolytic, 5 uf, 150 v	00656	E26G50
C7	2-4	CAPACITOR, Ceramic, 10 pf	71590	TCZ10
C8	2-7	CAPACITOR, Paper, 0.2 uf, 400 v	02777	P24D
C9	2-4	CAPACITOR, Paper, 10 uf, 200 v (matched)	02777	10P2D
C10	2-7	CAPACITOR, Ceramic, 0.01 uf	72982	851Z5U103Z
C11	2-4	CAPACITOR, Plastic, 1 uf, 400 v	02777	1P4M
C12	2-4	CAPACITOR, Ceramic, 1 pf	71590	TCZ1
C13	2-7	CAPACITOR, Mica, 330 pf (nominal)	72136	DM15E331F
C14	2-4	CAPACITOR, Mica, 15 pf	72136	DM15E150J
C15	2-7	CAPACITOR, Mica, 330 pf	72136	DM15E331F
C16	2-7	CAPACITOR, Paper, 0.2 uf, 400 v	02777	P24D
C17	2-8	CAPACITOR, Mica, 330 pf	72136	DM15E331F
C18	2-4	CAPACITOR, Mica, 110 pf	72136	DM15E111J
C19	2-7	CAPACITOR, Paper, 0.2 uf, 400 v	02777	P24D
C20	2-8	CAPACITOR, Electrolytic, 8 uf, 250 v	05571	TVA1503
C21	2-4	CAPACITOR, Paper, 10 uf, 200 v (matched)	02777	10P2D
C22	2-7	CAPACITOR, Ceramic, 0.01 uf	72982	851Z5U103Z
C23	2-4	CAPACITOR, Mica (selected value)	72136	DM15E---J
C24	2-4	CAPACITOR, Variable, ceramic, NP05-25 pf	88869	CA6
C25	2-4	CAPACITOR, Plastic, 4 uf, 200 v	02777	4P2M
C26	2-4	CAPACITOR, Electrolytic, 30 uf, 20 uf, 350 v, 100 uf, 150 v	05571	TVL3638-7
C27	2-4	CAPACITOR, Plastic, 2 uf, 200 v	02777	2P2M
C28	2-10	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C29	2-10	CAPACITOR, Paper, 0.5 uf, 200 v	02777	P52DS
C30	2-9	CAPACITOR, Mica, 220 pf	72136	DM15E221J
C31	2-9	CAPACITOR, Mica, 220 pf	72136	DM15E221J
C32	2-4	CAPACITOR, Ceramic, 0.01 uf	72982	851Z5U103Z

Parts List No. 1. Variable Phase Standard Model VPS-1 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
C33	2-9	CAPACITOR, Paper, 0.5 uf, 200 v	02777	P52DS
C34	2-4	CAPACITOR, Plastic, 1 uf, 200 v	02777	1P2M
C35	2-9	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C36	2-11	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C37	2-4	CAPACITOR, Mica, 110 pf	72136	DM15E111J
C38	2-11	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C39	2-4	CAPACITOR, Ceramic, 0.1 uf	72982	851Z5V104P
C40	2-11	CAPACITOR, Mica (selected value)	72136	DM19E---J
C41	2-11	CAPACITOR, Mica (selected value)	72136	DM15E---J
C42	2-8	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C43	2-8	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C44	2-11	CAPACITOR, Mica, 2000 pf	72136	DM19E202J
C201	2-5	CAPACITOR, Electrolytic, 2 x 40 uf, 450 v	05571	TVL2764
C202	2-10	CAPACITOR, Ceramic, 0.01 uf	72982	811Z5U103P
C203	2-5	CAPACITOR, Electrolytic, 2 x 40 uf, 450 v	05571	TVL2764
C204	2-9	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C205	2-5	CAPACITOR, Electrolytic, 2 x 40 uf, 400 v	05571	TVL2940
C206	2-9	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
C207	2-4	CAPACITOR, Ceramic, 0.01 uf	72982	811Z5U103P
C208	2-5	CAPACITOR, Electrolytic, 500 uf, 50 v	05571	TVL1330
C209	2-5	CAPACITOR, Electrolytic, 500 uf, 50 v	05571	TVL1330
C210	2-4	CAPACITOR, Ceramic, 0.1 uf	72982	827Z5V104P
CP1	2-3	PLUG, Adapter	71700	228
CR1	2-8	DIODE	96214	1N457
CR2	2-8	DIODE	96214	1N457
CR3	2-4	DIODE	81483	1N1512
CR201	2-10	DIODE	12060	DI58
CR202	2-10	DIODE	12060	DI58
CR203 thru	2-10	DIODE	12060	DI56
CR206	2-10	DIODE	12060	DI56
CR207 thru	2-10	DIODE	12060	DI58
CR210	2-10	DIODE	12060	DI58
CR211 thru	2-10	DIODE	12060	DI56
CR214	2-10	DIODE	12060	DI56
DS1	2-2	LAMP, Neon	08806	NE51H
DS201	2-2	LAMP, Incandescent	08806	49
F1	2-2	FUSE, 1.5 amp	03614	MDL1 1-2
F201	2-2	FUSE, 1.5 amp (for 115 v operation)	03614	MDL1 1-2
F201	2-2	FUSE, 0.75 amp (for 230 v operation)	03614	MDL3-4
F202	2-3	FUSE, 0.2 amp (for 115 v operation)	03614	MDL2-10
F202	2-2	FUSE LAMP (for 230 v operation)	03614	MDL1-10
H1 thru	2-2	KNOB, Bar	88869	OP1
H12	2-2	KNOB, Bar	88869	OP1
H13 thru	2-2	KNOB, Medium, black	75376	S656-3LBBBLK
H15	2-2	KNOB, Medium, black	75376	S656-3LBBBLK
H16 thru	2-2	KNOB, Small, red	75376	S645-5LRED
H18	2-2	KNOB, Small, red	75376	S645-5LRED
HR1	2-5	LAMP, Incandescent, 10 v	08806	344
J1	2-3	POST, Binding, red	58474	DF30RC
J2	2-3	POST, Binding, black	58474	DF30BC
J3	2-4	CONNECTOR, Receptacle	75173	S310AB
J4	2-4	CONNECTOR, Receptacle, red	76487	37001RED
J5	2-4	CONNECTOR, Receptacle, black	76487	37001BLK
J6	2-4	CONNECTOR, Receptacle, yellow	76487	37501

Parts List No. 1. Variable Phase Standard Model VPS-1 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
J7	2-2	POST, Binding, red	58474	DF30RC
J8	2-2	POST, Binding, black	58474	DF30BC
J9	2-2	POST, Binding, red	58474	DF30RC
J10	2-2	POST, Binding, black	58474	DF30BC
J11	2-3	POST, Binding, red	58474	DF30RC
J12	2-3	POST, Binding, black	58474	DF30BC
J13	2-3	POST, Binding, red	58474	DF30RC
J14	2-3	POST, Binding, black	58474	DF30BC
J202	2-5	CONNECTOR, Receptacle	75173	S304AB
L1	2-4	CHOKE, 500 mh	81095	EM500A
M1	2-2	METER, Null	88869	AW262
P1	2-6	CONNECTOR, Plug	75173	P310CCTL
P2	2-6	CONNECTOR, Plug, red (part of 37001RED)		
P3	2-6	CONNECTOR, Plug, black (part of 37001BLK)		
P4	2-6	CONNECTOR, Plug, yellow (part of 37501)		
P201	2-3	CONNECTOR, Plug	75173	P304CCT
R1	2-4	RESISTOR, Film, 210k ±1%, 1/2 w	11350	210KFCA15
R2	2-4	RESISTOR, Variable, 25k (dual potentiometer)	88869	RV40
R3	2-4	RESISTOR, Film, 210k ±1%, 1/2 w	11350	210KFCA15
R4	2-8	RESISTOR, Composition, 200k ±10%, 1/2 w		COML
R6	2-8	RESISTOR, Film, 10k ±1%, 1/2 w	11350	10KFCA15
R7	2-8	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R8	2-8	RESISTOR, Film, 1m ±1%, 1/2 w	11350	1MFCA15
R9	2-4	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R10	2-4	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R11	2-4	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R12	2-8	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R13	2-8	RESISTOR, Wirewound, 30k ±3%, 5 w	04387	3PCT30KRLS5
R14	2-3	RESISTOR, Variable, 2k	80294	200S1-202M
R15	2-4	RESISTOR, Film (selected value)	11350	TYPE FCA15
R16	2-4	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R17	2-4	RESISTOR, Film, 392k ±1%, 1/2 w	11350	392KFCA15
R18	2-7	RESISTOR, Composition, 68k ±10%, 1/2 w		COML
R19	2-7	RESISTOR, Composition, 47k ±10%, 1/2 w		COML
R20	2-4	RESISTOR, Film, 392k ±1%, 1/2 w	11350	392KFCA15
R21	2-7	RESISTOR, Film, 470k ±1%, 1/2 w	11350	470KFCA15
R22	2-4	RESISTOR, Composition, 330k ±10%, 1/2 w		COML
R23	2-7	RESISTOR, Film, 1m ±1%, 1/2 w	11350	1MFCA15
R24	2-7	RESISTOR, Film, 2.2m ±1%, 1/2 w	11350	2-2MFCA15
R30	2-5	RESISTOR, Variable, 20 ohms	80294	200S1-200
R31	2-7	RESISTOR, Composition, 18k ±10%, 2 w		COML
R32	2-7	RESISTOR, Composition, 680k ±10%, 1/2 w		COML
R33	2-7	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R34	2-4	RESISTOR, Wirewound, 20 ohms ±1%	04387	1PCT20RS1A
R35	2-4	RESISTOR, Wirewound, 20 ohms ±1%, 1 w	04387	1PCT20RS1A
R36	2-11	RESISTOR, Wirewound (selected)	04387	TYPE RS1A
R37	2-11	RESISTOR, Wirewound, 15k ±1%, 2-1/2 w	04387	1PCT15KRS2C
R38	2-11	RESISTOR, Wirewound (selected)	04387	TYPE RS1A
R39	2-4	RESISTOR, Variable, 1k	88869	RV41
R40	2-11	RESISTOR, Wirewound (selected)	04387	TYPE RS1A
R41	2-11	RESISTOR, Wirewound (selected)	04387	TYPE RS1A
R42	2-11	RESISTOR, Wirewound, 15k ±1%, 2-1/2 w	04387	1PCT15KRS2C
R43	2-9	RESISTOR, Film, 30k ±1%, 1/2 w	11350	30KFCA15
R44	2-4	RESISTOR, Composition, 68k ±10%, 1/2 w		COML
R45	2-5	RESISTOR, Variable, 20 ohms	80294	200S1-200
R49	2-4	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R50	2-4	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R51	2-4	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R52	2-4	RESISTOR, Composition, 39k ±10%, 1/2 w		COML
R53	2-4	RESISTOR, Composition, 39k ±10%, 1/2 w		COML

Parts List No. 1. Variable Phase Standard Model VPS-1 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
R54	2-4	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R55	2-7	RESISTOR, Composition, 6.8k ±10%, 1/2 w		COML
R56	2-7	RESISTOR, Composition, 100k ±10%, 1 w		COML
R57	2-7	RESISTOR, Film, 2.2m ±1%, 1/2 w	11350	2-2MFCA15
R58	2-4	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R59	2-7	RESISTOR, Film, 2.2m ±1%, 1/2 w	11350	2-2MFCA15
R60	2-7	RESISTOR, Composition, 68k ±10%, 2 w		COML
R61	2-4	RESISTOR, Film, 196k ±1%, 1/2 w	11350	196KFCA15
R62	2-4	RESISTOR, Film, 100k ±1%, 1/2 w	11350	100KFCA15
R63	2-8	RESISTOR, Film, 2.2k ±1%, 1/2 w	11350	2-2KFCA15
R64	2-4	RESISTOR, Film, 40k ±1%, 1/2 w	11350	40KFCA15
R65	2-8	RESISTOR, Film, 30k ±1%, 1/2 w	11350	30KFCA15
R66	2-8	RESISTOR, Film, 196k ±1%, 1/2 w	11350	196KFCA15
R67	2-8	RESISTOR, Film, 196k ±1%, 1/2 w	11350	196KFCA15
R68	2-7	RESISTOR, Film, 2.2m ±1%, 1/2 w	11350	2-2MFCA15
R69	2-4	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R70	2-7	RESISTOR, Film, 2.2m ±1%, 1/2 w	11350	2-2MFCA15
R71	2-8	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R72	2-7	RESISTOR, Composition, 18k ±10%, 2 w		COML
R73	2-7	RESISTOR, Composition, 680k ±10%, 1/2 w		COML
R74	2-7	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R75	2-4	RESISTOR, Wirewound, 20 ohms ±1%, 1 w	04387	1PCT20RS1A
R76	2-4	RESISTOR, Wirewound, 20 ohms ±1%, 1 w	04387	1PCT20RS1A
R77	2-4	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R78	2-10	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R79	2-10	RESISTOR, Film, 330k ±1%, 1/2 w	11350	330KFCA15
R80	2-10	RESISTOR, Wirewound, 4k ±3%, 3 w	04387	3PCT4KRS2B
R81	2-10	RESISTOR, Composition, 470 ohms ±10%, 1/2 w		COML
R82	2-10	RESISTOR, Film, 196k ±1%, 1/2 w	11350	196KFCA15
R83	2-10	RESISTOR, Film, 330k ±1%, 1/2 w	11350	330KFCA15
R84	2-3	RESISTOR, Variable, 200k	80294	215S1-204M
R85	2-10	RESISTOR, Film, 1m ±1%, 1/2 w	11350	1MFCA15
R86	2-10	RESISTOR, Composition, 4.7k ±10%, 1/2 w		COML
R87	2-10	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R88	2-10	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R89	2-10	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R90	2-9	RESISTOR, Film, 100k ±1%, 1/2 3	11350	100KFCA15
R91	2-9	RESISTOR, Film, 100k ±1%, 1/2 w	11350	100KFCA15
R92	2-9	RESISTOR, Composition, 470k ±10%, 1/2 w		COML
R93	2-9	RESISTOR, Film, 10k ±1%, 1/2 w	11350	10KFCA15
R94	2-9	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R95	2-9	RESISTOR, Composition, 68k ±10%, 1 w		COML
R96	2-9	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R97	2-9	RESISTOR, Composition, 27k ±10%, 1/2 w, nom (selected)		COML
R98	2-9	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R99	2-9	RESISTOR, Composition, 22k ±10%, 2 w		COML
R100	2-11	RESISTOR, Film, 330k ±1%, 1/2 w	11350	330KFCA15
R101	2-11	RESISTOR, Composition, 2.7k ±10%, 1/2 w		COML
R102	2-11	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R103	2-11	RESISTOR, Composition, 330k ±10%, 1/2 w		COML
R104	2-11	RESISTOR, Composition, 2.7k ±10%, 1/2 w		COML
R105	2-11	RESISTOR, Composition, 4.7k ±10%, 1/2 w		COML
R106	2-4	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R107	2-8	RESISTOR, Composition, 2.2k ±10%, 1/2 w		COML
R108	2-4	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R109	2-8	RESISTOR, Composition, 22k ±10%, 1/2 w		COML
R110	2-8	RESISTOR, Composition, 22k ±10%, 1/2 w		COML
R111	2-8	RESISTOR, Composition, 22k ±10%, 1/2 w		COML
R112	2-8	RESISTOR, Composition, 10k ±10%, 1/2 w		COML

Parts List No. 1. Variable Phase Standard Model VPS-1 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
R113	2-8	RESISTOR, Variable, 20k	80294	215S1-203
R114	2-4	RESISTOR, Composition, 100k ±10%		COML
R115	2-11	RESISTOR, Composition (selected)		COML
R116	2-6	RESISTOR, 1k ±10%, 1/2 w		COML
R117	2-6	RESISTOR, 47 ohms ±10%, 1/2 w		COML
thru				
R121	2-6	RESISTOR, 47 ohms ±10%, 1/2 w		COML
R124	2-6	RESISTOR, 1k ±10%, 1/2 w		COML
R125	2-6	RESISTOR, 47 ohms ±10%, 1/2 w		COML
thru				
R129	2-6	RESISTOR, 47 ohms ±10%, 1/2 w		COML
R202	2-10	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R203	2-10	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R204	2-10	RESISTOR, Composition, 220k ±10%, 1 w		COML
R205	2-10	RESISTOR, Composition, 68k ±10%, 1/2 w		COML
R206	2-10	RESISTOR, Composition, 470k ±10%, 1/2 w		COML
R207	2-10	RESISTOR, Composition, 120k ±10%, 1/2 w		COML
R208	2-10	RESISTOR, Variable, 25k	04061	JA1L040S253UC
R209	2-10	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R211	2-4	RESISTOR, Composition, 1m ±10%, 1/2 w		COML
R212	2-4	RESISTOR, Composition, 470k ±10%, 1/2 w		COML
R213	2-9	RESISTOR, Composition, 470k ±10%, 1/2 w		COML
R214	2-9	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R215	2-9	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R216	2-9	RESISTOR, Composition, 10 ohms ±10%, 1/2 w		COML
R217	2-9	RESISTOR, Composition, 10 ohms ±10%, 1/2 w		COML
R218	2-9	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R219	2-9	RESISTOR, Composition, 27k ±10%, 1/2 w		COML
R220	2-9	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R221	2-9	RESISTOR, Composition, 150k ±10%, 1/2 w		COML
R222	2-9	RESISTOR, Variable, 25k	04061	JA1L040S253UC
R223	2-4	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R224	2-9	RESISTOR, Composition, 470k ±10%, 1/2 w		COML
R225	2-9	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R226	2-9	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R227	2-9	RESISTOR, Composition, 10 ohms ±10%, 1/2 w		COML
R228	2-9	RESISTOR, Composition, 10 ohms ±10%, 1/2 w		COML
R229	2-9	RESISTOR, Composition, 10k ±10%, 2 w		COML
R230	2-9	RESISTOR, Composition, 4.7k ±10%, 1 w		COML
R231	2-9	RESISTOR, Composition, 120k ±10%, 1/2 w		COML
R232	2-9	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R233	2-9	RESISTOR, Variable, 25k	04061	JA1L040S253UC
R234	2-9	RESISTOR, Composition, 120k ±10%, 1/2 w		COML
R235	2-9	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R236	2-4	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R237	2-4	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R238	2-4	RESISTOR, Wirewound, 25 ohms, 10 w	83777	25MOR10
R239	2-4	RESISTOR, Wirewound, 3.3 ohms ±3%, 2-1/2 w	04387	2PCT3-3RS2C
R240	2-4	RESISTOR, Composition, 20 ohms ±5%, 1 w		COML
R243	2-4	RESISTOR, Composition, 470 ohms ±10%, 1/2 w		COML
R244	2-4	RESISTOR, Composition, 470 ohms ±10%, 1/2 w		COML
R245	2-4	RESISTOR, Composition, 10 ohms ±10%, 2 w		COML
R246	2-10	RESISTOR, Composition, 470k ±10%, 1/2 w		COML
thru				
R255	2-10	RESISTOR, Composition, 470k ±10%, 1/2 w		COML
RV1	2-9	VARISTOR	72819	BNR200K4V3-7K25V
S1	2-4	SWITCH	88869	SW77
S2	2-6	SWITCH	88869	SW99
S3	2-2	SWITCH		ST26N

Parts List No. 1. Variable Phase Standard Model VPS-1 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
S4	2-4	SWITCH	88869	SW75
S5	2-3	SWITCH		ST26N
S6	2-2	SWITCH	88869	SW98
S7	2-6	SWITCH	88869	S54
thru				
S18	2-6	SWITCH	88869	S54
S201	2-2	SWITCH	73559	2BL6273
T1A	2-11	TRANSFORMER	88869	TA185
T1B	2-11	TRANSFORMER	88869	TA186
T2	2-11	TRANSFORMER	88869	TA187
T3	2-11	TRANSFORMER	88869	TA184
T4A	2-6	TRANSFORMER	88869	TA185
T4B	2-6	TRANSFORMER	88869	TA186
T5	2-6	TRANSFORMER	88869	TA187
T6	2-4	TRANSFORMER	88869	TA245
T7	2-6	TRANSFORMER	88869	TA186
T201	2-4	TRANSFORMER	88869	TP7
T202	2-4	TRANSFORMER	88869	TA276
TB201	2-5	TERMINAL BOARD	71785	1774-5101P24
TB202	2-5	TERMINAL BOARD	71785	1774-5101P24
TP1	2-3	JACK, Red	74970	108-902
V1	2-5	TUBE, Electron		12AX7
V2	2-5	TUBE, Electron		12AU7
V3	2-5	TUBE, Electron		9U8A
V4	2-5	TUBE, Electron		12AU7
V5	2-5	TUBE, Electron		7722
V6	2-5	TUBE, Electron		12AU7
V7	2-5	TUBE, Electron		9U8A
V8	2-5	TUBE, Electron		12AU7
V9	2-5	TUBE, Electron		7247
V10	2-5	TUBE, Electron		12AT7
V11	2-5	TUBE, Electron		12AT7
V12	2-5	TUBE, Electron		7025
V13	2-5	TUBE, Electron		12AT7
V201	2-5	TUBE, Electron		6U8A
V202	2-5	TUBE, Electron		6BX7
V203	2-5	TUBE, Electron		6DK6
V204	2-5	TUBE, Electron		6BX7
V205	2-5	TUBE, Electron		6DK6
V206	2-5	TUBE, Electron		OA2
W1	2-3	CABLE, Power	70903	17406S
XDS1	2-2	LIGHT, Indicator	87034	VM312-6
XDS201	2-2	LIGHT, Indicator	87034	VM312-6
XF1	2-2	FUSEHOLDER	75915	342004
XF201	2-2	FUSEHOLDER	75915	342004
XF202	2-3	FUSEHOLDER	75915	342004
XV1	2-5	SOCKET, Tube	71785	44F24760
thru				
XV13	2-5	SOCKET, Tube	71785	44F24760
XV201	2-5	SOCKET, Tube	71785	44F24760
XV202	2-5	SOCKET, Tube	71785	51B16759
XV203	2-5	SOCKET, Tube	71785	53C24761
XV204	2-5	SOCKET, Tube	71785	51B16759
XV205	2-5	SOCKET, Tube	71785	53C24761
XV206	2-5	SOCKET, Tube	71785	53C24761
XZ1	2-5	SOCKET, Tube (3 required)	71785	53C24761
XZ2	2-5	SOCKET, Tube (3 required)	71785	53C24761
Z1	2-5	NETWORK, Oscillator	88869	AA930-FREQ
Z2	2-5	NETWORK, Quadrature	88869	AA929-FREQ

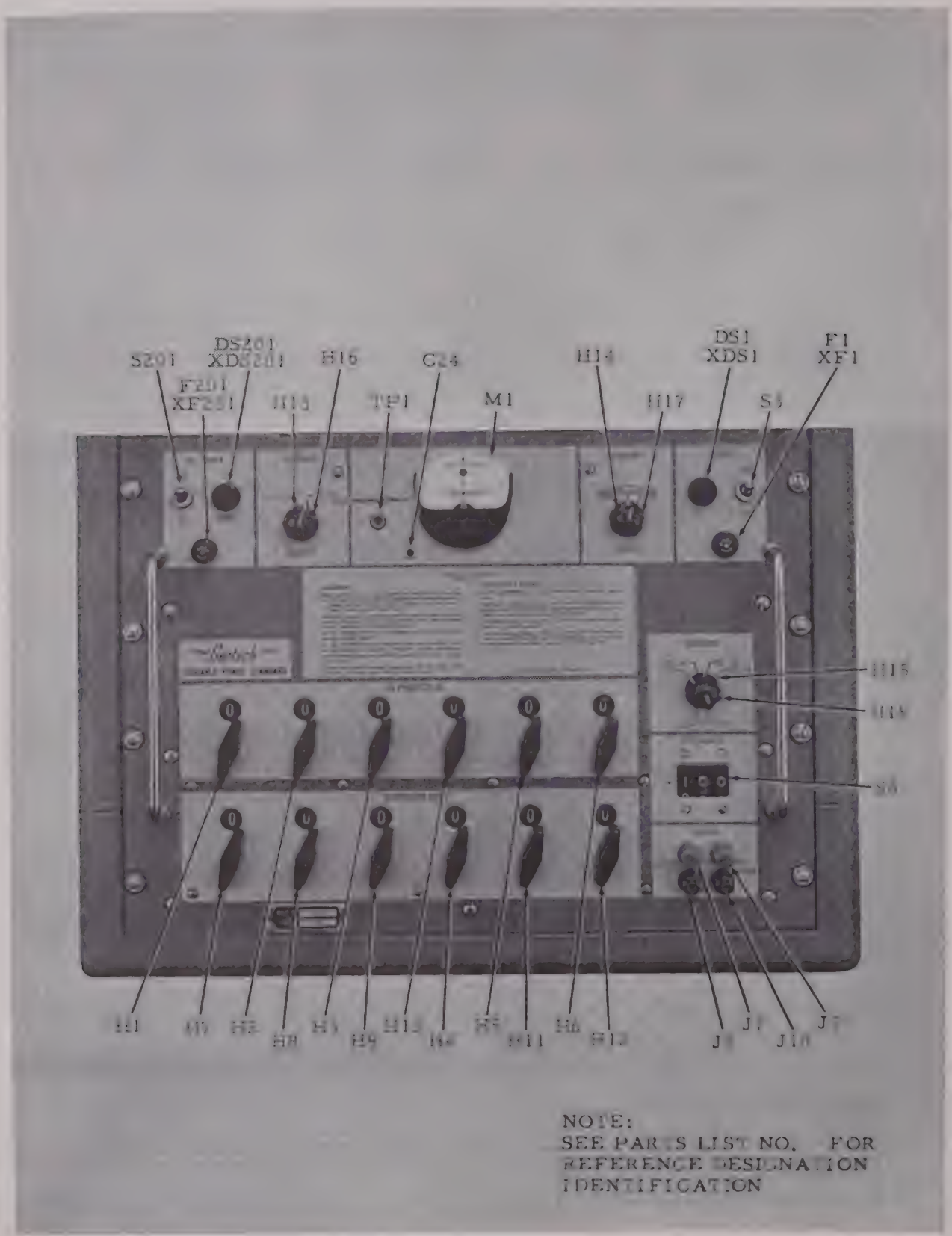


Figure 2-2. Variable Phase Standard Model VPS-1, Front View

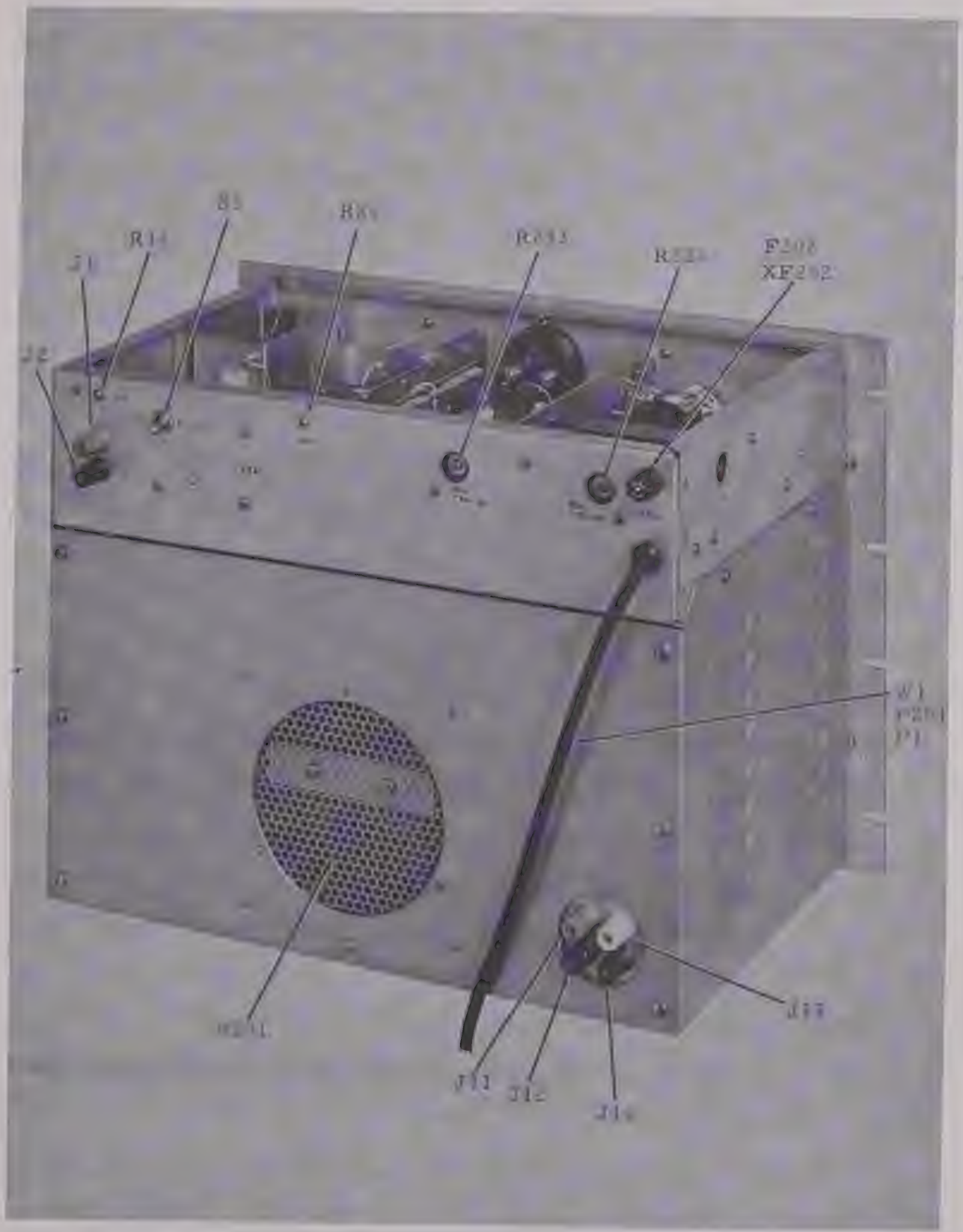


Figure 2-3. Variable Phase Standard Model VPS-1, Back View

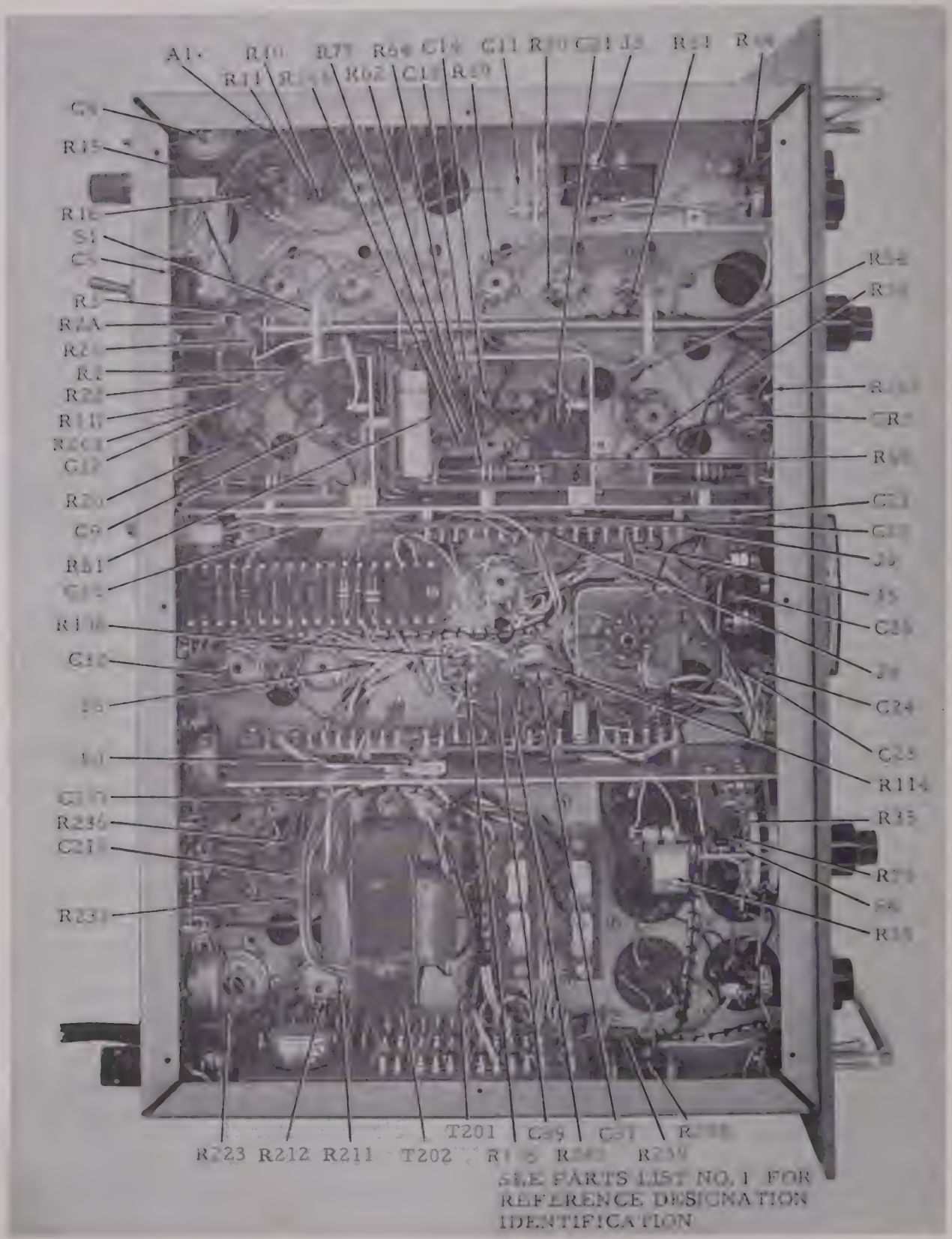


Figure 2-4. Variable Phase Standard Model VPS-1, Amplifier Chassis

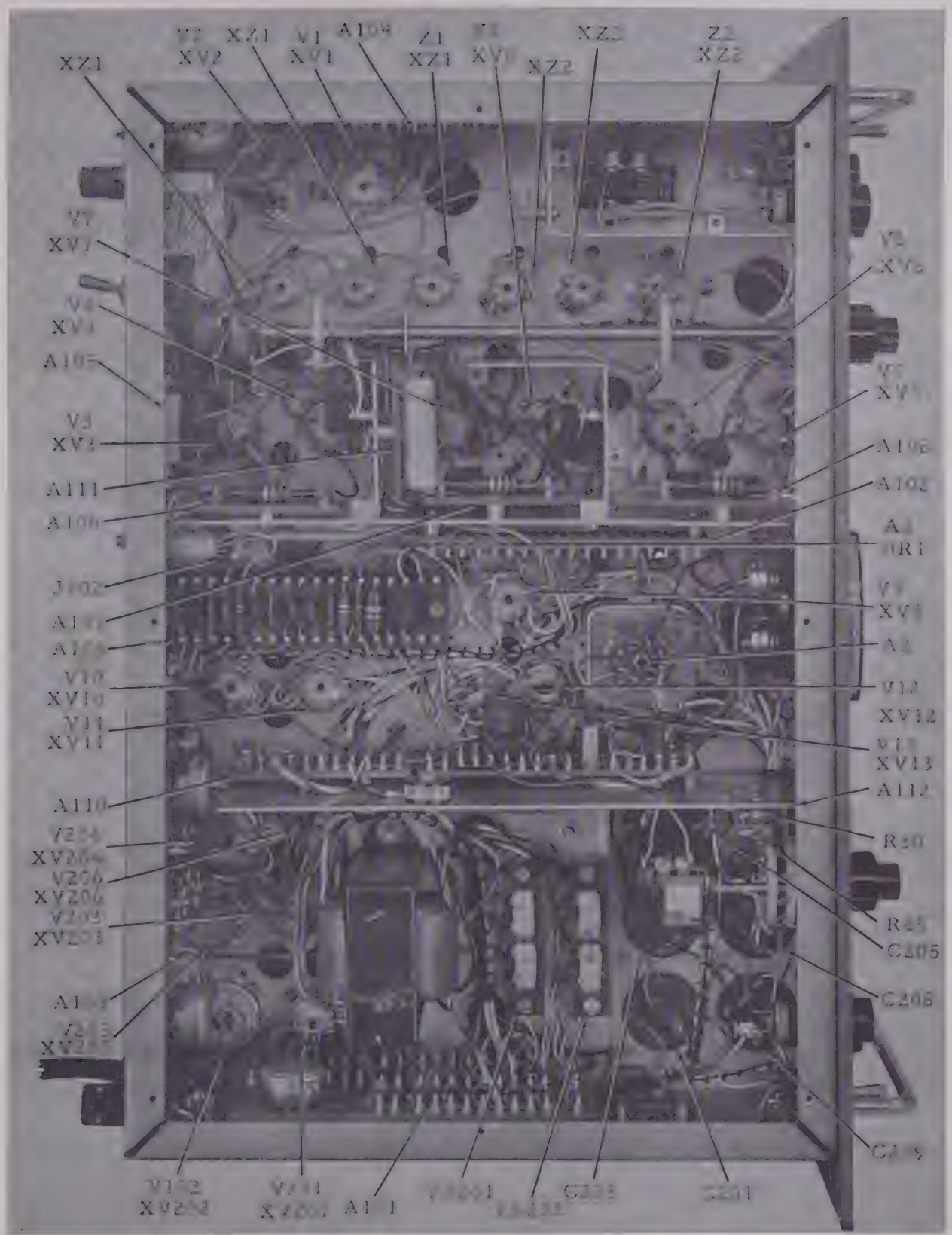


Figure 2-5. Variable Phase Standard Model VPS-1, Amplifier Chassis

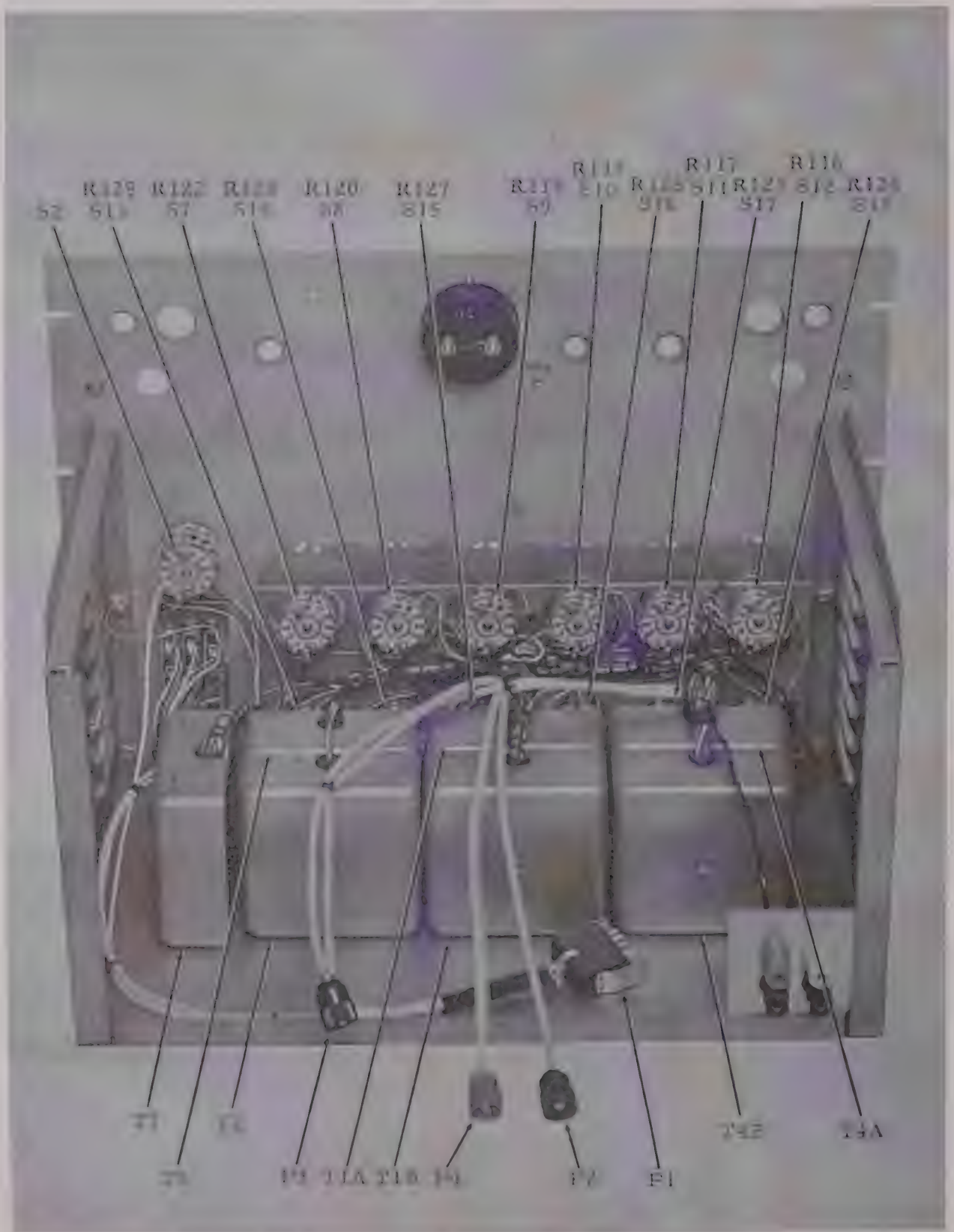


Figure 2-6. Variable Phase Standard Model VPS-1, Internal View

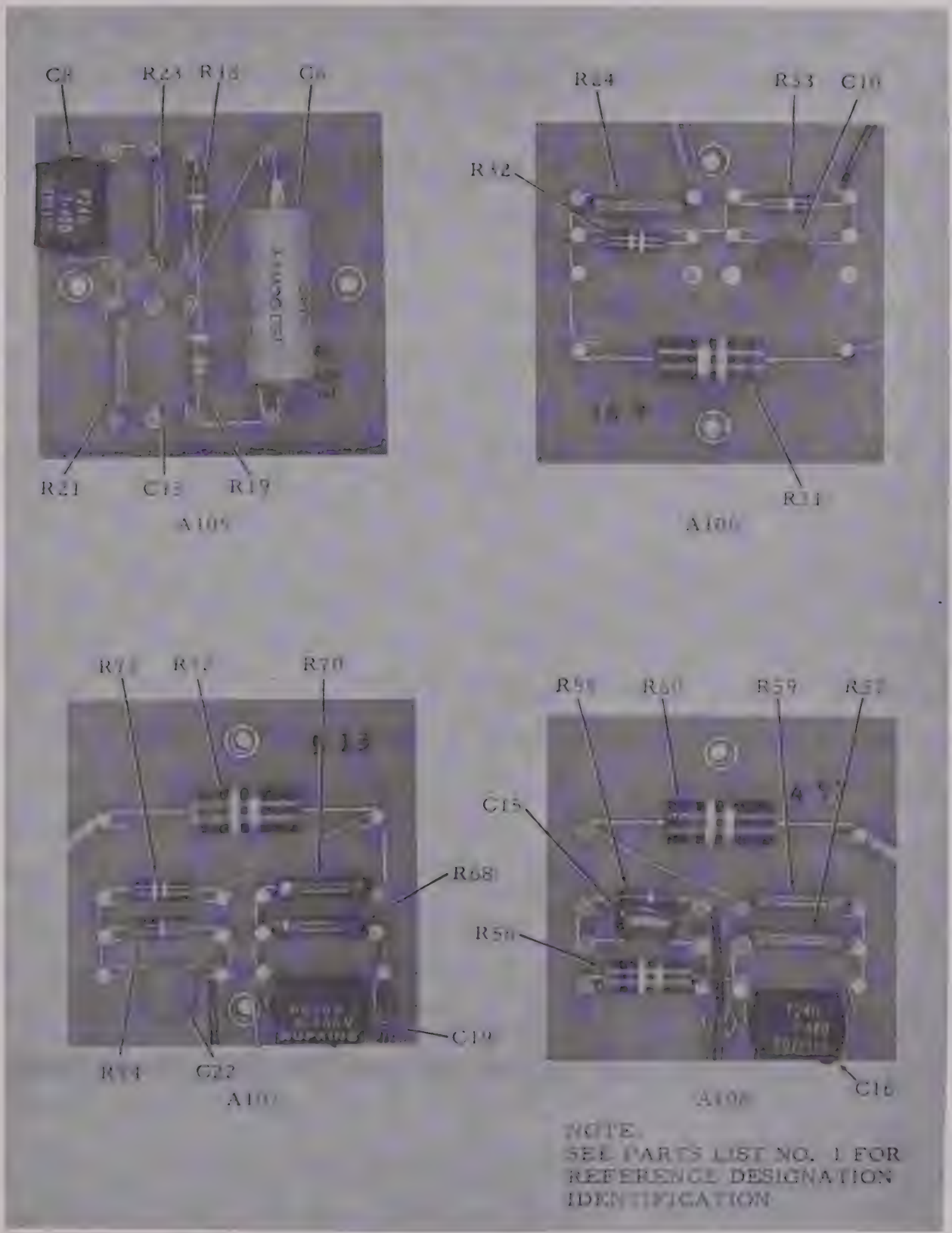


Figure 2-7. Terminal Board Assemblies

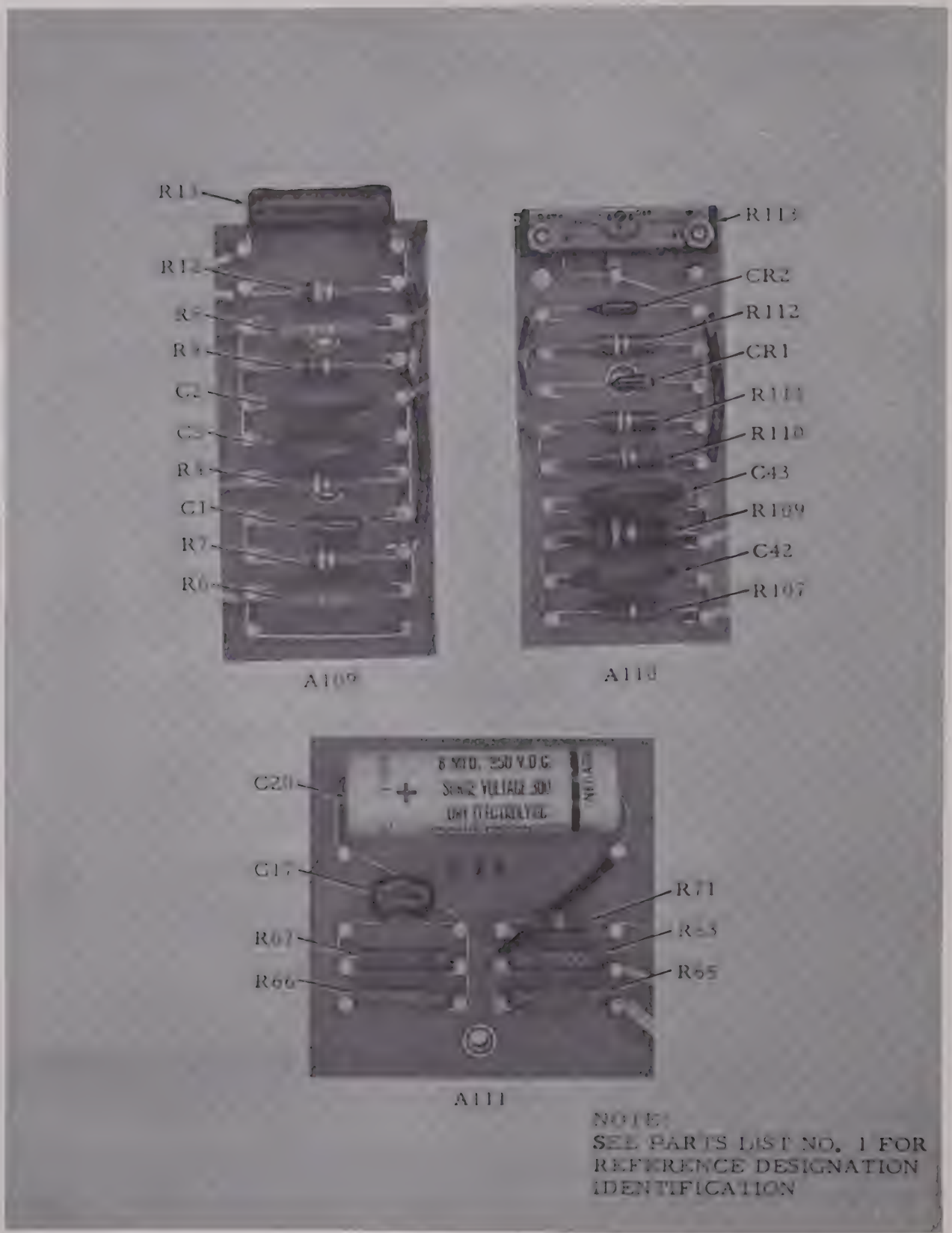


Figure 2-8. Terminal Board Assemblies

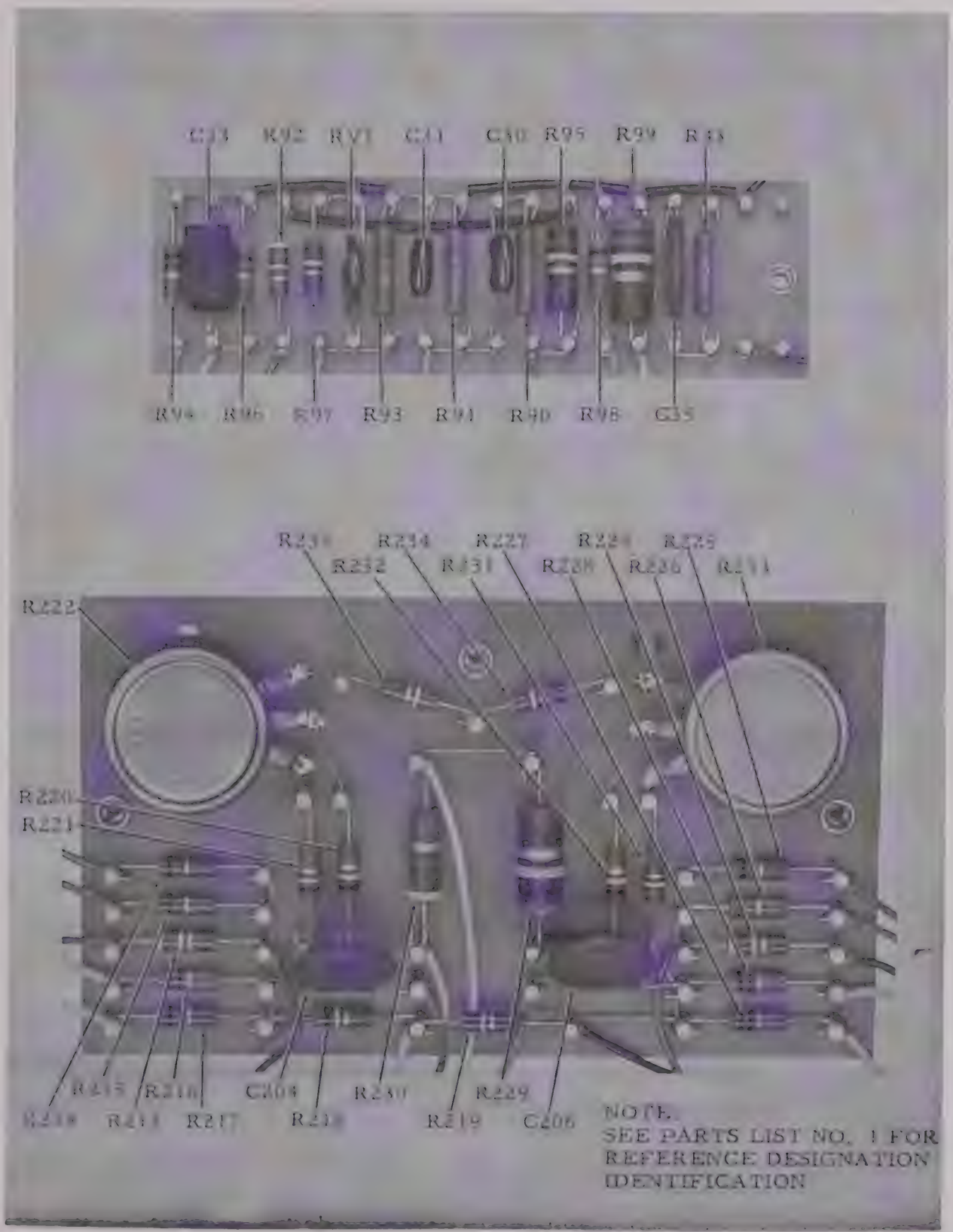


Figure 2-9. Terminal Board Assemblies

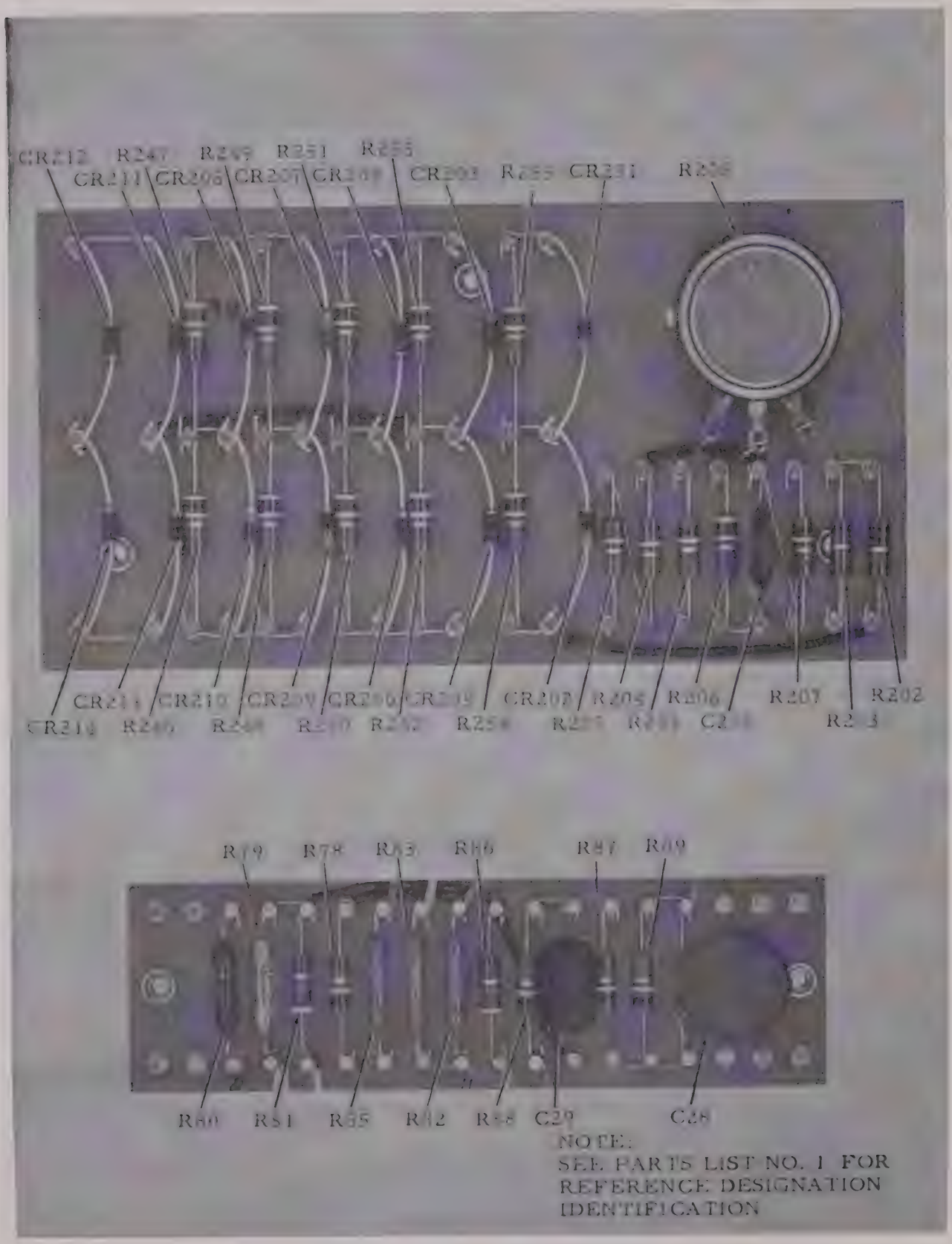


Figure 2-10. Terminal Board Assemblies

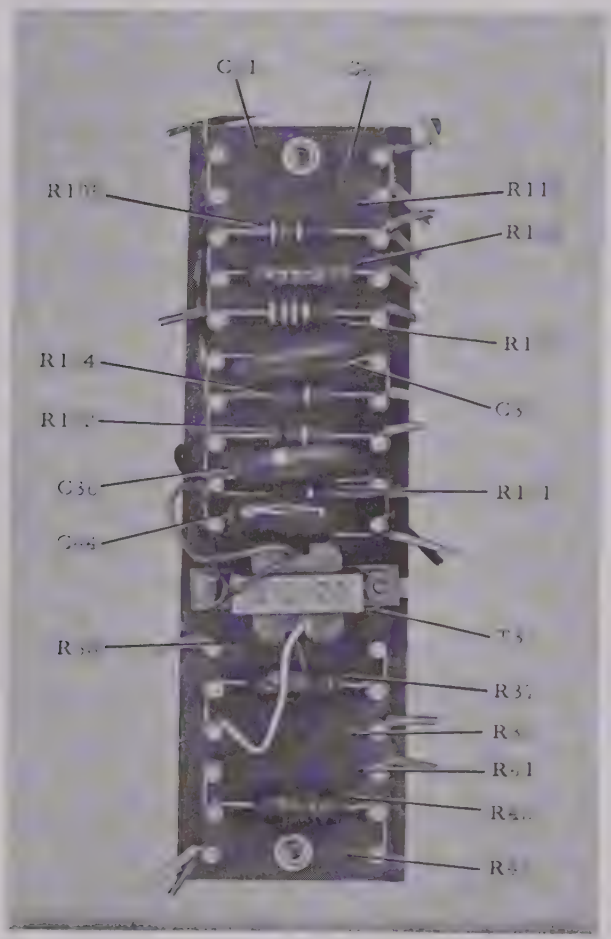


Figure 2-11. Terminal Board Assembly

Parts List No. 2. Quadrature Standard Model QS-1

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
A101	2-12	ATTENUATOR ASSY	88869	AA803
A102	2-12	TERMINAL BOARD ASSY, Quadrature generator (See figure 2-13)		AA713
A201	2-12	ATTENUATOR ASSY	88869	AA803
A202	2-12	TERMINAL BOARD ASSY, Quadrature generator (See figure 2-13)	88869	AA711
C101	2-13	CAPACITOR, Electrolytic, 20 uf, 50 v	05571	TE1305
C102	2-13	CAPACITOR, Metalized paper, 0.5 uf, 200 v	02777	P52DS
C103	2-13	CAPACITOR, Plastic, .015 uf	84411	663UW-015UF 200V
C104	2-13	CAPACITOR, Electrolytic, 150 uf, 6 v	05571	TE1103
C105	2-13	CAPACITOR, Electrolytic, 50 uf, 50 v	05571	TE1307
C201	2-13	CAPACITOR, Electrolytic, 20 uf, 50 v	05571	TE1305
C202	2-13	CAPACITOR, Metalized paper, 0.5 uf, 200 v	02777	P52DS
C203	2-13	CAPACITOR, Plastic, .015 uf	84411	663UW-015UF 200V
C204	2-13	CAPACITOR, Electrolytic, 150 uf, 6 v	05571	TE1103
C205	2-13	CAPACITOR, Electrolytic, 50 uf, 50 v	05571	TE1307
C301	2-12	CAPACITOR, Electrolytic, 120 uf, 150 v	09023	BR15015
C302	2-12	CAPACITOR, Electrolytic, 50 uf, 50 v	05571	TE1307
C303	2-12	CAPACITOR, Electrolytic, 20 uf, 100 v	05571	TE1409
C304	2-12	CAPACITOR, Electrolytic, 50 uf, 15 v	05571	TE1133
C501	2-12	CAPACITOR, Electrolytic, 20 uf, 50 v	05571	TE1305
C502	2-12	CAPACITOR, Electrolytic, 150 uf, 6 v	05571	TE1103
C503	2-12	CAPACITOR, Electrolytic, 5 uf, 50 v	05571	TE1303
C504	2-12	CAPACITOR, Electrolytic, 50 uf, 50 v	05571	TE1307
CP101	2-12	ADAPTER, Plug	71700	228
CR301	2-12	DIODE, Silicon	12060	DI56
CR302	2-12	DIODE, Silicon	12060	DI56
CR303	2-12	DIODE, Silicon	12060	DI56
CR304	2-12	DIODE, Silicon	12060	DI56
CR305	2-12	DIODE, Zener	80211	1N3028B
CR306	2-12	DIODE, Zener	81483	1N1509
DS301	2-12	LAMP, Neon	08806	NE51H
F301	2-12	FUSE, Slow blow, 0.5A (for 115 v operation)	03614	MDL1/2
F301	2-12	FUSE, Slow blow, 0.25A (for 230 v operation)	03614	MDL1/4
H101	2-12	KNOB, Function control	88869	AA537
H102	2-12	KNOB, Input voltage selector	88869	AA537
H103	2-12	KNOB, Phase control	88869	AA537
H104	2-12	KNOB, Phase control	88869	AA537
H105	2-12	KNOB, Gain control	75376	S656-3L
H106	2-12	KNOB, Gain control	75376	S656-3L
H107	2-12	KNOB, Vernier control	75376	S645-5L
H108	2-12	KNOB, Vernier control	75376	S645-5L
H109	2-12	KNOB, Frequency control	88869	OP9
J401	2-12	CONNECTOR, BNC		UG657/U
J402	2-12	CONNECTOR, BNC		UG657/U
J403	2-12	POST, Binding, red	58474	DF30RC
J404	2-12	POST, Binding, black	58474	DF30BC
J405	2-12	POST, Binding, black	58474	DF30BC
J406	2-12	POST, Binding, yellow	58474	DF30YC
Q101	2-13	TRANSISTOR	93332	2N417
Q102	2-13	TRANSISTOR	88869	EP11
Q103	2-13	TRANSISTOR	88869	EP11
Q201	2-13	TRANSISTOR	93332	2N417
Q202	2-13	TRANSISTOR	88869	EP11
Q203	2-13	TRANSISTOR	88869	EP11
Q301	2-12	TRANSISTOR	80211	2N1363
Q302	2-12	TRANSISTOR	88869	EP11
Q501	2-12	TRANSISTOR	88869	EP11
Q502	2-12	TRANSISTOR	88869	EP11

Parts List No. 2. Quadrature Standard Model QS-1 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
R1 thru R9	2-12	RESISTOR, Composition, 909 ohms ±1%, 1/4 w	75042	RN65B9090F
R101	2-13	RESISTOR, Composition, 10 ohms ±10%, 1/2 w		COML
R102	2-12	POTENTIOMETER, 1k ±10%, 2 w	89536	22A1K
R103	2-13	POTENTIOMETER, 1k ±10%, 2 w	89536	22A1K
R104	2-13	RESISTOR, Deposited carbon, 33.2k ±1%, 1/2 w	75042	RN65B3322F
R105	2-13	RESISTOR, Composition, 39k ±10%, 1 w		COML
R106	2-13	RESISTOR, Composition, 6.8k ±10%, 1/2 w		COML
R107	2-13	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R108	2-13	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R109	2-13	RESISTOR, Composition, 47k ±10%, 1/2 w		COML
R110	2-13	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R111	2-13	RESISTOR, Composition, 1.2k ±10%, 1/2 w		COML
R112	2-13	RESISTOR, Composition, 4.7k ±10%, 1/2 w		COML
R113	2-13	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R201	2-13	RESISTOR, Composition, 10 ohms ±10%, 1/2 w		COML
R202	2-13	POTENTIOMETER, 1k ±10%, 2 w	89536	22A1K
R203	2-13	POTENTIOMETER, 1k ±10%, 2 w	89536	22A1K
R204	2-13	RESISTOR, Deposited carbon, 33.2k ±1%, 1/2 w	75042	RN65B3322F
R205	2-13	RESISTOR, Composition, 39k ±10%, 1 w		COML
R206	2-13	RESISTOR, Composition, 6.8k ±10%, 1/2 w		COML
R207	2-13	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R208	2-13	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R209	2-13	RESISTOR, Composition, 47k ±10%, 1/2 w		COML
R210	2-13	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R211	2-13	RESISTOR, Composition, 1.2k ±10%, 1/2 w		COML
R212	2-13	RESISTOR, Composition, 4.7k ±10%, 1/2 w		COML
R213	2-13	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R301	2-13	RESISTOR, Composition, 68k ±10%, 1/2 w		COML
R302	2-13	RESISTOR, Composition, 8.2k ±10%, 1/2 w		COML
R303	2-13	RESISTOR, Composition, 150 ohms ±10%, 1/2 w		COML
R304	2-12	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R305	2-12	RESISTOR, Composition, 1.8k ±10%, 1/2 w		COML
R306	2-12	POTENTIOMETER, Trim, 1k ±10%, 1/4 w	80294	236P1-102
R307	2-12	RESISTOR, Composition, 1.8k ±10%, 1/2 w		COML
R308	2-12	RESISTOR, Composition, 10k ±10%, 1 w		COML
R501	2-12	RESISTOR, Composition, 47k ±10%, 1/2 w		COML
R502	2-12	RESISTOR, Composition, 39k ±10%, 1/2 w		COML
R503	2-12	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R504	2-12	RESISTOR, Composition, 1.2k ±10%, 1/2 w		COML
R505	2-12	RESISTOR, Composition, 180k ±10%, 1/2 w		COML
R506	2-12	RESISTOR, Composition, 68k ±10%, 1/2 w		COML
R507	2-12	RESISTOR, Composition, 4.7k ±10%, 1/2 w		COML
R508	2-12	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
S301	2-12	SWITCH, Toggle	95691	20902JH
S401	2-12	SWITCH, Rotary	88869	SW72
S402	2-12	SWITCH, Rotary	88869	SW73
S403	2-12	SWITCH, Rotary	88869	SW73
S404	2-12	SWITCH, Rotary	88869	SW131
T301	2-12	TRANSFORMER, Power	88869	TP13
T401	2-12	TRANSFORMER, Scaling	88869	TA248
T402	2-12	TRANSFORMER, Summing	88869	TA247
T403	2-12	TRANSFORMER, Summing	88869	TA247
TB1	2-13	TERMINAL BOARD	88869	AA714
TB2	2-13	TERMINAL BOARD, Printed	88869	AA712
TB3	2-13	TERMINAL BOARD, Printed	88869	AA709
TB5	2-12	TERMINAL BOARD, Printed	88869	AA716
TS301	2-12	TERMINAL, Strip	71785	1774-5101P24
TS302	2-12	TERMINAL, Strip	71785	1510A

Parts List No. 2. Quadrature Standard Model QS-1 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
W101	2-12	CORD, Power	70903	17406S
XDS301	2-12	LAMPHOLDER, Red	72619	145-5036-991
XF301	2-12	FUSEHOLDER, Miniature, type 3AG	75915	342004
XZ101	2-12	SOCKET	71785	53C24761
XZ201	2-12	SOCKET	71785	53C24761
Z101	2-12	NETWORK, Quadrature	88869	AA626-5
Z201	2-12	NETWORK, Quadrature	88869	AA626-5

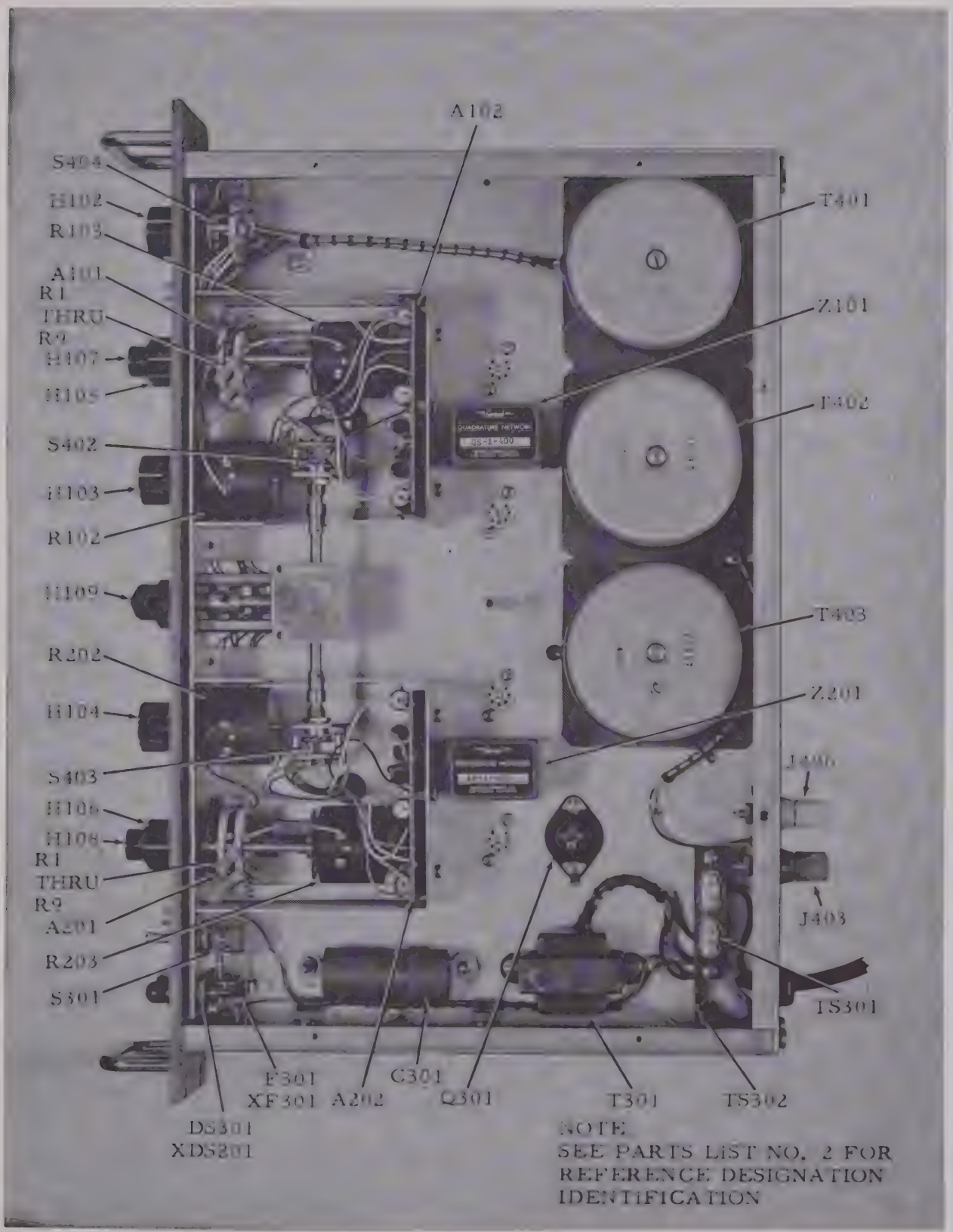


Figure 2-12. Quadrature Standard Model QS-1 (Sheet 1 of 2)

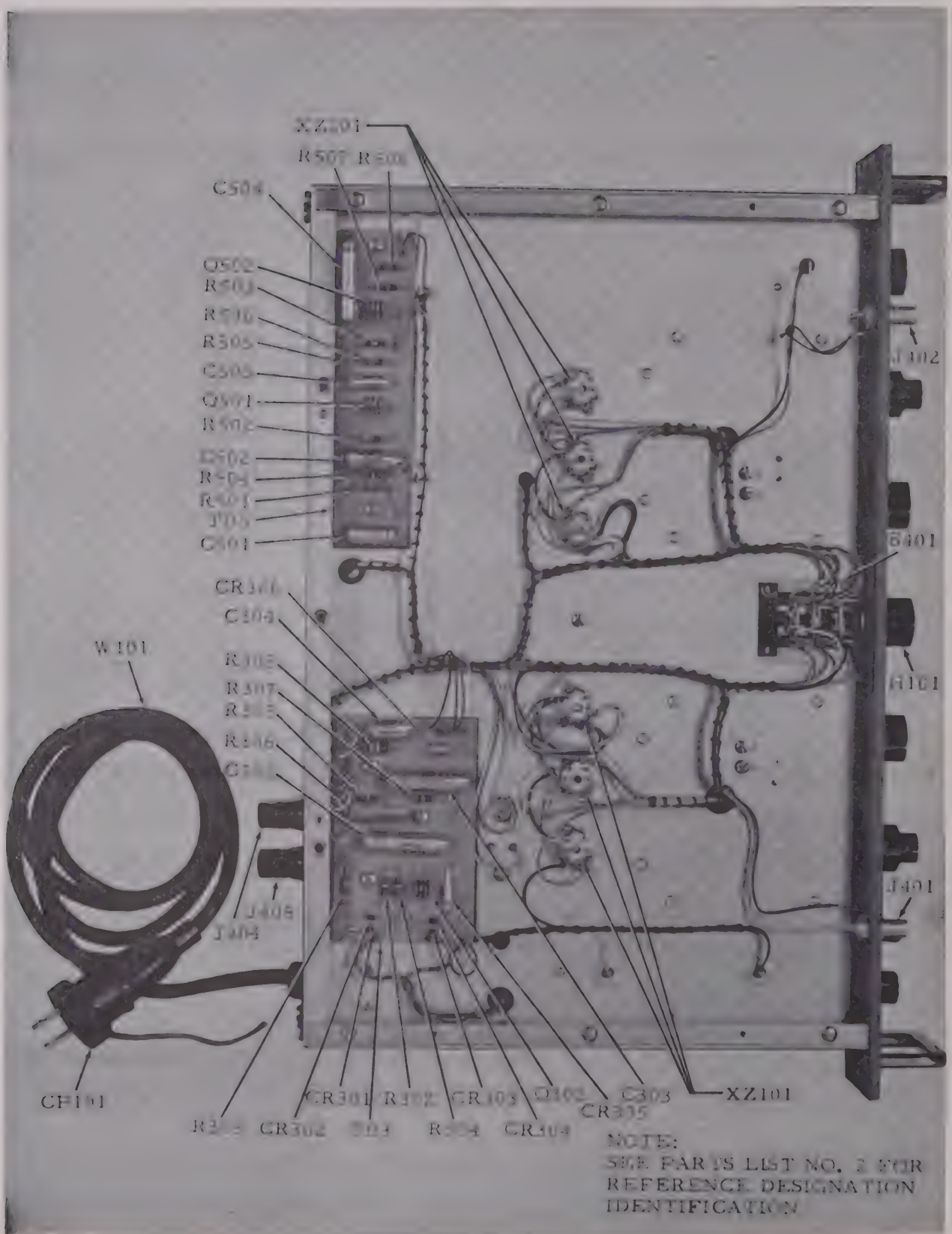


Figure 2-12. Quadrature Standard Model QS-1 (Sheet 2 of 2)

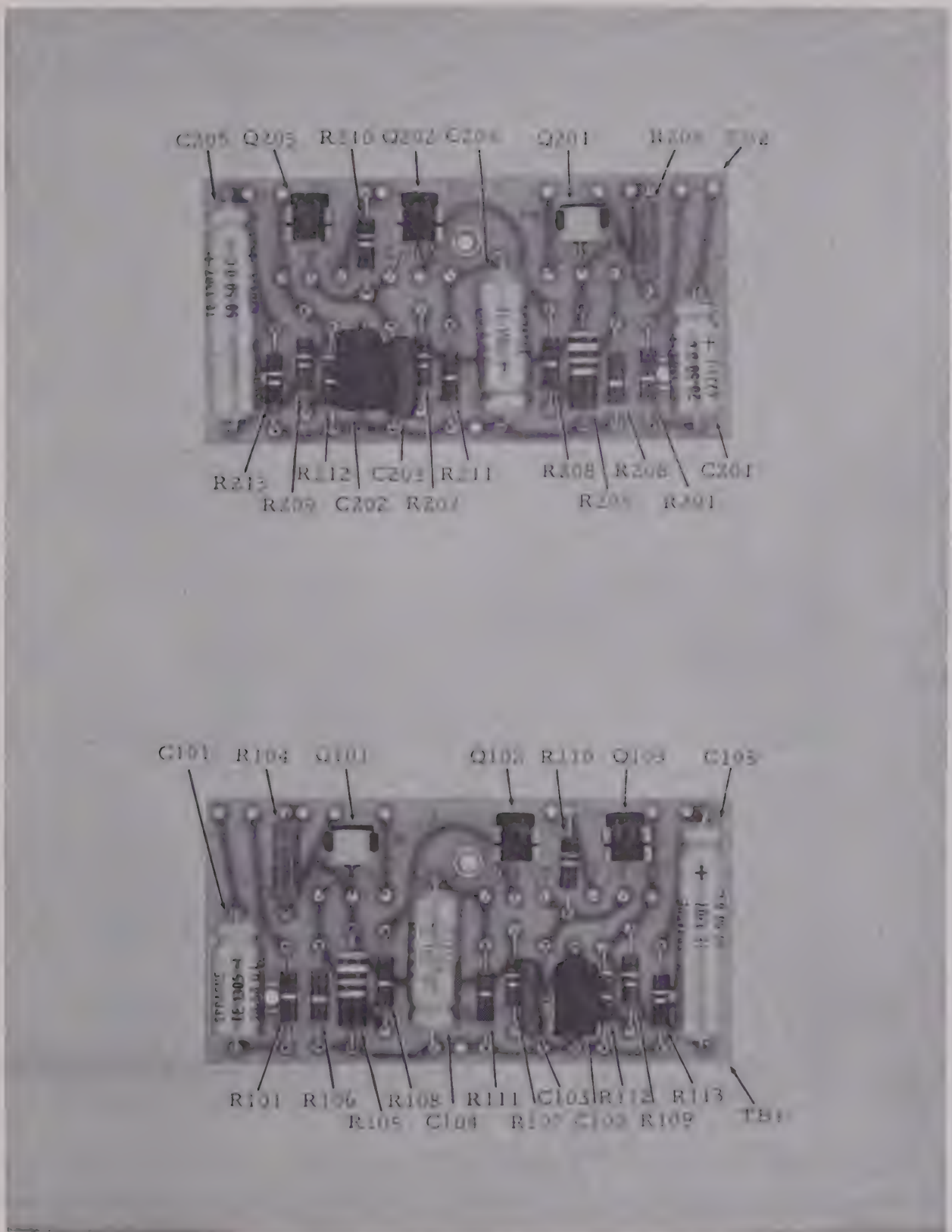


Figure 2-13. Terminal Board Assemblies

Parts List No. 3. Null Indicator Model NI-4

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
A201	2-14	TERMINAL BOARD ASSY, Null amplifier (See figure 2-15)	88861	AA818-5
C101	2-15	CAPACITOR, Variable ceramic, 3 to 12 pf	72982	503N5003-12
C102	2-15	CAPACITOR, Variable, ceramic, 7 to 45 pf	72982	503N5007-45
C103	2-15	CAPACITOR, Mica, 500 pf	72136	DM15E501K
C104	2-15	CAPACITOR, Ceramic, 15 pf	71590	TCZ15
C105	2-15	CAPACITOR, Metalized paper, 0.5 uf, 200 v	02777	P52DS
C106	2-15	CAPACITOR, Ceramic, 0.001 uf	72982	861Z5U102Z
C107	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
C108	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
C110	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
C111	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
C112	2-15	CAPACITOR, Electrolytic, 500 uf, 3 v	05571	TE1068
C113	2-15	CAPACITOR, Plastic, 0.015 uf	84411	663UW-015UF 200V
C114	2-15	CAPACITOR, Electrolytic, 300 uf, 6 v	05571	TE1106
C115	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
C116	2-15	CAPACITOR, Electrolytic, 500 uf, 3 v	05571	TE1068
C117	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
C118	2-15	CAPACITOR, Electrolytic, 300 uf, 6 v	05571	TE1106
C119	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
C120	2-14	CAPACITOR, Electrolytic, 250 uf, 50 v	05571	TVA1213
C121	2-14	CAPACITOR, Electrolytic, 250 uf, 50 v	05571	TVA1312
C122	2-14	CAPACITOR, Paper, 0.5 uf, 200 v	02777	P52DS
C123	2-14	CAPACITOR (selected value)		
C124	2-14	CAPACITOR (selected value)		
C125	2-14	CAPACITOR (selected value)		
C134	2-15	CAPACITOR, Electrolytic, 15 uf, 12 v	05571	TE1129
CR101	2-15	DIODE	73293	1N457
CR102	2-15	DIODE	73293	1N457
CR103	2-15	DIODE	12065	1N273
CR104	2-15	DIODE	12065	1N273
CR105	2-15	DIODE	73293	1N457
CR106	2-15	DIODE	73293	1N457
CR107	2-15	DIODE	73293	1N457
CR108	2-15	DIODE	73293	1N457
CR113	2-14	DIODE	81483	1N1512
CR114	2-14	RECTIFIER, Bridge	88869	EP46-1
DS101	2-14	LAMP, Neon	08806	NE2J
F101	2-14	FUSE, 1/10 amp (for 115 v operation)	03614	MDL1-10
F101	2-14	FUSE, 1/16 amp (for 230 v operation)	03614	MDL1-16
FL101	2-14	FILTER, 400 cps	88869	BPF400B
H201	2-14	KNOB	88869	AA537
H202	2-14	KNOB	88869	AA537
H203	2-14	KNOB	88869	AA537
J101	2-14	POST, Binding, red	58474	DF30RC
J102	2-14	POST, Binding, black	58474	DF30BC
J103	2-14	POST, Binding, red	58474	DF30RC
J104	2-14	POST, Binding, black	58474	DF30BC
J105	2-15	JACK, Test, red	74970	108902
J106	2-15	JACK, Test, black	74970	108903
J107	2-14	POST, Binding, black	58474	DF30BC
J109	2-14	POST, Binding, black	58474	DF30BC
J110	2-14	POST, Binding, yellow	58474	DF30YC
M101	2-14	METER, Null	88869	AW262
P101	2-14	CONNECTOR, Plug (part of W101)		
Q101 thru Q106	2-15	TRANSISTOR	94154	2N417
	2-15	TRANSISTOR	94154	2N417

Parts List No. 3. Null Indicator Model NI-4 (Cont)

REF DES	FIG. NO.	DESCRIPTION	VENDOR CODE	PART NUMBER
R101	2-15	RESISTOR, Film, 1 mego ±1%, 1/4 w		RN65B1004F
R102	2-15	RESISTOR, Film, 100k ±1%, 1/4 w		RN65B1003F
R103	2-15	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
R105	2-15	RESISTOR, Composition, 22k ±10%, 1/2 w		COML
R106	2-15	RESISTOR, Composition, 180k ±10%, 1/2 w		COML
R107	2-15	RESISTOR, Composition, 180k ±10%, 1/2 w		COML
R108	2-15	RESISTOR, Composition, 100k ±10%, 1/2 w		COML
R109	2-15	RESISTOR, Composition, 1.2k ±10%, 1/2 w		COML
R110	2-15	RESISTOR, Composition, 22k ±10%, 1/2 w		COML
R111	2-15	RESISTOR, Composition, 22k ±10%, 1/2 w		COML
R112	2-15	RESISTOR, Composition, 4.7k ±10%, 1/2 w		COML
R114	2-15	RESISTOR, Composition, 8.2k ±10%, 1/2 w		COML
R115	2-15	RESISTOR, Composition, 220 ohms ±10%, 1/2 w (nominal value)		COML
R116	2-15	RESISTOR, Composition, 2.2k ±10%, 1/2 w		COML
R117	2-15	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R118	2-15	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R119	2-15	RESISTOR, Composition, 220 ohms ±10%, 1/2 w		COML
R120	2-15	RESISTOR, Composition, 1.8k ±10%, 1/2 w		COML
R121	2-15	RESISTOR, Composition, 4.7k ±10%, 1/2 w		COML
R122	2-15	RESISTOR, Composition, 8.2k ±10%, 1/2 w		COML
R123	2-15	RESISTOR, Composition, 2.2k ±10%, 1/2 w		COML
R124	2-15	RESISTOR, Composition, 220k ±10%, 1/2 w		COML
R125	2-15	RESISTOR, Composition, 1k ±10%, 1/2 w		COML
R126	2-15	RESISTOR, Composition, 470 ohms ±10%, 1/2 w		COML
R127	2-15	RESISTOR, Composition, 470 ohms ±10%, 1/2 w		COML
R128	2-15	RESISTOR, Composition, 220 ohms ±10%, 1/2 w		COML
R129	2-15	RESISTOR, Composition, 1.5k ±10%, 1/2 w		COML
R132	2-15	RESISTOR, Composition, 47k ±10%, 1/2 w		COML
R133	2-15	RESISTOR, Composition, 47k ±10%, 1/2 w		COML
R134	2-15	RESISTOR, Composition, 2.2k ±10%, 1/2 w		COML
R135	2-15	RESISTOR, Composition, 2.2k ±10%, 1/2 w		COML
R136	2-15	RESISTOR, Composition, 2.2k ±10%, 1/2 w		COML
R137	2-15	RESISTOR, Composition, 2.2k ±10%, 1/2 w		COML
R139	2-14	RESISTOR, Composition, 820 ohms ±10%, 1 w		COML
R143	2-14	RESISTOR, Composition, 68k ±10%, 1/2 w		COML
R169	2-14	RESISTOR, Variable, 5k	88869	RV42-2
R170	2-15	RESISTOR, Composition, 10k ±10%, 1/2 w		COML
S101	2-14	SWITCH, Rotary	88869	SW92
S104	2-14	SWITCH, Rotary	88869	SW92
S105	2-14	SWITCH, Toggle		ST26N
S106	2-14	SWITCH, Toggle		ST26N
T101	2-14	TRANSFORMER, Reference	88869	TA165
T102	2-14	TRANSFORMER, Power	88869	TA262
TB101	2-14	TERMINAL BOARD	71785	1774-5101P24
TB102	2-14	TERMINAL BOARD	71785	1510A
W101	2-14	CABLE ASSY, Power	70903	17406S
XDS101	2-14	LIGHT, Indicator	72619	145-5036-991
XF101	2-14	FUSEHOLDER	75915	342004
XFL100	2-14	SOCKET, Tube (3 required)	71785	53C24761

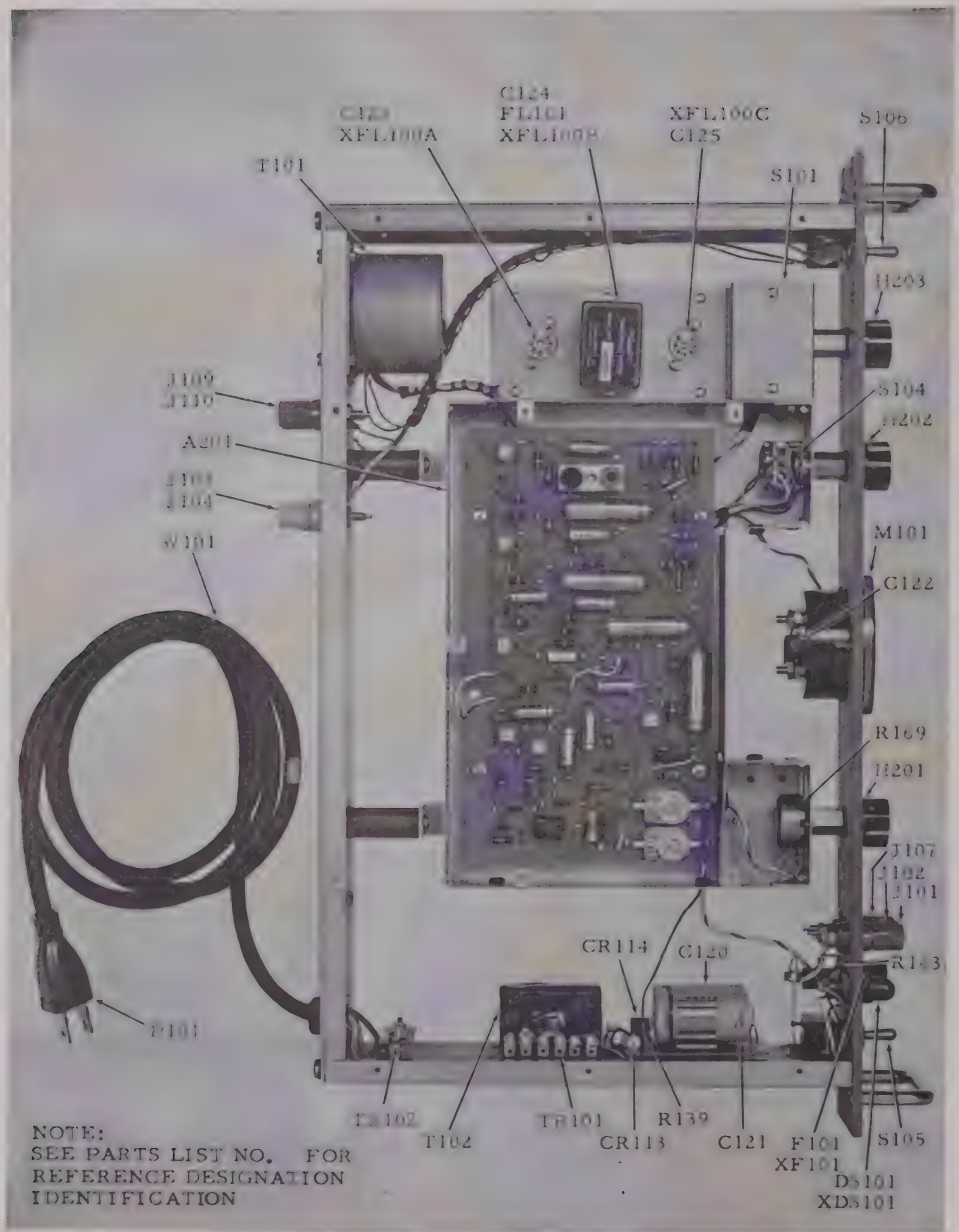


Figure 2-14. Null Indicator Model NI-4

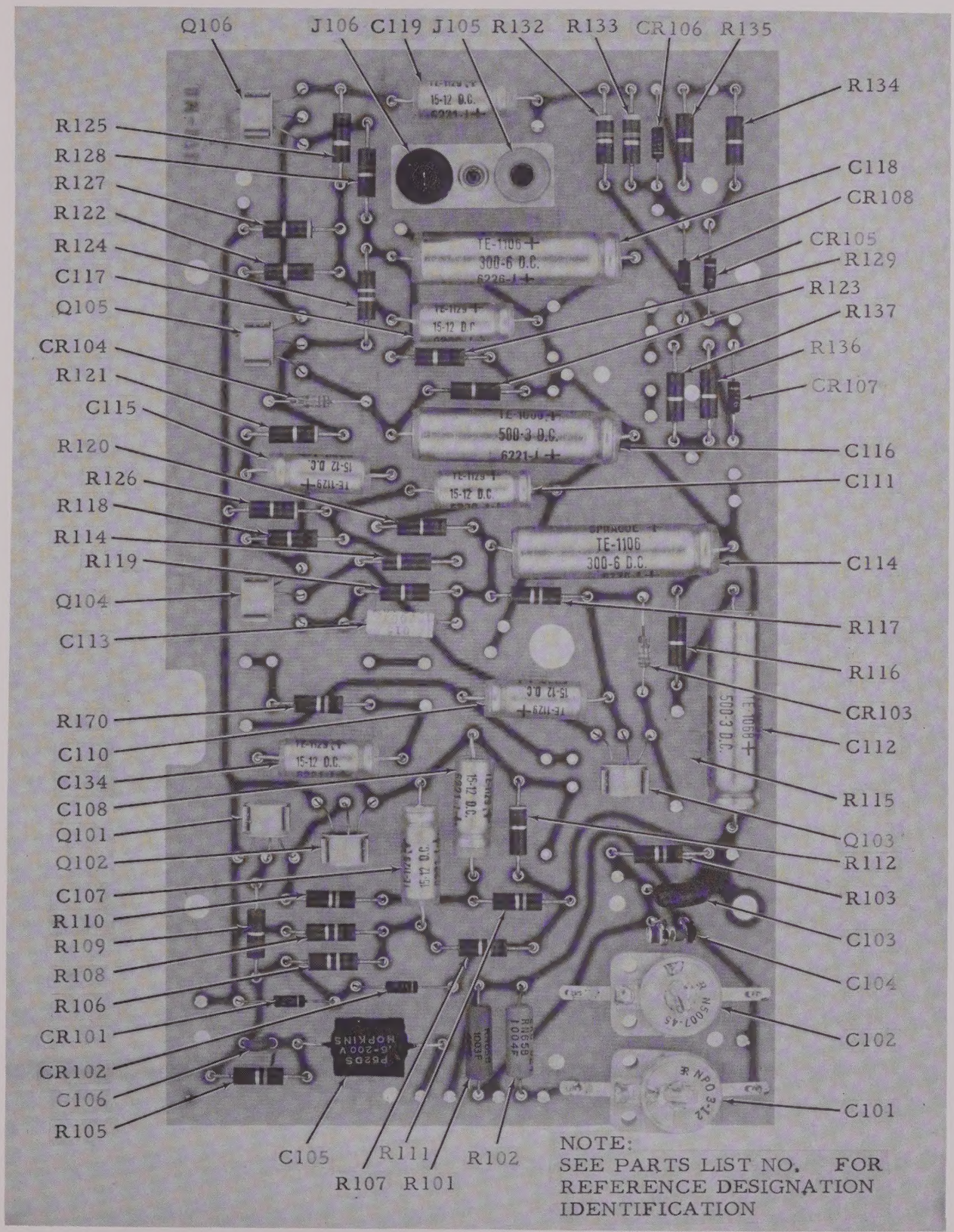


Figure 2-15. Terminal Board Assembly

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